



# U.S. Government Funding of Cooperative Research and Development in North America

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# U.S. Government Funding of Cooperative Research and Development in North America

CAROLINE S. WAGNER  
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*MR-1115-OSTP*

Supported by the  
Office of Science and Technology Policy

**RAND**

Science and Technology Policy Institute

This report presents findings from research conducted by the Science and Technology Policy Institute at RAND. This report describes the results of a RAND inventory of U.S. government spending on North American cooperation in research and development (R&D) between 1993 and 1997 and characterizes the nature of these activities.

The findings herein should be of interest to government policymakers concerned about international relations in science and technology and to those in the science and technology community interested in tracking R&D spending. This project's Web home page is <http://www.rand.org/centers/stpi/stp>. For access to the RaDiUS Web page, go to <https://radius.rand.org/>.

Research and data analysis for this report was conducted by the authors, aided by Monica Pinto, formerly of the RAND staff. The project was requested by and conducted under the guidance of Deanna Behring, National Security and International Affairs Division, Office of Science and Technology Policy (OSTP), Executive Office of the President. Conclusions in this report are RAND's alone and should not be ascribed to the Office of Science and Technology Policy or the National Science Foundation.

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The U.S. government funds cooperative R&D projects in and with counterparts in Canada and Mexico. Since 1993, U.S. government agencies have spent more than \$100 million a year on projects involving cooperation with Canada and/or Mexico. A variety of motives and missions drive this investment. The activities funded have been focused primarily on common interests and problems in environmental, agricultural, and earth sciences, as well as on biomedical and genetic research. Formal collaboration puts Canada and Mexico among the U.S. government's top 10 binational R&D partners. (Wagner, 1997, pp. 17-19.)

Funds for collaborative activities with Canada and Mexico, with a few exceptions, are not set aside specifically for this purpose. Collaboration with our neighbors arises in two ways: One, when a U.S. government agency determines that a joint project is in the interests of the mission needs of that agency, such as a Department of Agriculture study of forest monitoring project at the borders, and two, when a U.S. government-funded researcher identifies a partner in Canada or Mexico with whom collaboration would be in the interests of a scientific inquiry, such as a comparison by university-based biomedical researchers of the efficacy of heart bypass surgery. The benefits of collaboration are determined at the program or researcher level and are generally based upon a need to access data or natural resources or otherwise to link to excellent research taking place in Canada or Mexico.

The U.S. government's R&D relationships with these two countries differ in character. The R&D relationship with Canada has the quality of a partnership between equals. The scientific exchanges are reciprocal, active, and robust. There are few formal agreements to conduct scientific exchange. In contrast, the relationship with Mexico, while sound and growing, is not an equal exchange. The relationship is more formal (having less informal scientist-to-scientist exchange), and there are more government-to-government agreements to engage in cooperative activities. Moreover, there are more one-way transfers of information and assistance from the United States to Mexico than there are such relationships with Canada. Cooperation with Canada focuses on scientific or technical questions, but cooperative projects with Mexico focus more on specific problems, such as water pollution or land management. Moreover, while the United States has an active cooperative relationship with Canada in both defense and space R&D (the areas in which the United States spends the majority of its R&D funds), there is little of this type of activity with Mexico.

Cooperation within North American in science and technology can be expected to increase over the next decade. Canada and Mexico continue to make investments in their national science and technology enterprises in ways that provide opportunities for enhanced cooperation. Both countries have increased their gross domestic expenditures in R&D over the past decade. In addition, the number of university-trained R&D personnel in each country has also risen. Positive economic outlooks for these countries also contribute to the likelihood that investments in science and technology will flourish.

Despite a growing commitment to science and technology, the U.S. relationships with Canada and Mexico will continue to differ in character. Canada's scientific culture is closer to that of the United States. Canada operates among the leading scientific nations in the world. National investment and publication patterns show Canada, like other leading nations, moving away from the "older" sciences, such as physics and chemistry, toward modern life-science disciplines. (Okubo et al., 1992, p. 333.) Table S.1 shows the areas of scientific specialization of the North American countries based upon publication data. Canada's profile more closely matches that of the United States.

Mexico's pattern of international collaboration tracks more closely with those of India, Brazil, Argentina, and Venezuela, countries characterized by having mature scientific infrastructures and globally active industrial sectors. (Okubo et al., 1992, p. 342.) Analysis of publication patterns shows that Mexican scientists are more likely to publish with Brazilian and Venezuelan scientists than with U.S. partners, perhaps because of a similarity among those countries in language and culture. (Okubo et al., 1992, p. 342.) Moreover, these countries continue to invest significant R&D funds in the physical sciences, such as physics and chemistry, which support a growing industrial base.

Although the relationships among the three North American countries will differ based upon the nature of the science and technology infrastructure in each country, there are opportunities for enhanced cooperation between the United States and its neighbors and among the three nations. With Mexico, in particular, opportunities for greater U.S.-Mexico scientist-to-scientist cooperation are evident:

**Table S.1**  
**Areas of Scientific Specialization, as Revealed by**  
**Publication Counts**

1995 Data	Canada	Mexico	United States
Field with largest number of national articles	Clinical medicine	Physics	Clinical medicine
Field with second largest number of articles	Biomedical research	Clinical medicine	Biomedical research
Field with third largest number of articles	Biology	Biomedical research	Physics
Field with fourth largest number of articles	Chemistry	Biology	Chemistry

SOURCE: NSB (1998).

1. research projects in which a U.S. researcher is working in Mexico without an active Mexican partner
2. education and training
3. high-technology areas, such as electronics and communications.

With Canada, too, opportunities for enhanced cooperation emerge from joint interests of the United States and Canada in natural and scientific resources. Interest in forest monitoring has grown in both the United States and Canada as environmental research has become a priority for these countries. The United States and Canada share ecosystem resources on the border that require monitoring and tending. Canada has been aggressive about using remote-sensing technology to monitor forests.<sup>1</sup> Cooperation in collection and analysis of both remotely sensed and in situ forest monitoring would benefit both countries.

Trinational activities are the most promising area for enhanced cooperation. U.S. government funding for trinational activities amounts to about \$2 million per year. The three countries have a number of environmental, agricultural, health, and space interests in common. In particular, oceans, forests, water, and atmosphere offer research opportunities for North American collaboration.

Identifying these opportunities may require a more strategic approach to decision-making about some areas of U.S. government-funded scientific research. There is often a tension in R&D funding between bottom-up, merit-based research funding and top-down, mission-oriented research. The challenge here is to mobilize resources toward the support of North American science, while allowing researchers to retain autonomy, and to give scientists a role in decisionmaking.

One way to accommodate strategic goals and scientific excellence is to provide funding through such centers as the U.S.-Mexico Science and Technology Foundation. Funds provided to a group like this could have a strategic focus on specific issues and problems while still allowing a peer review committee to determine what projects should be funded and who receives support. Establishing a three-way science and technology foundation or commission may allow each nation to provide support to North American science and technology issues. Similarly, a special event, such as a North American science and technology week, and accompanying internships and fellowships may provide opportunities to link researchers together.

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<sup>1</sup>RAND research.

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## ABBREVIATIONS

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CDC	Centers for Disease Control and Prevention
CONACYT	Consejo Nacional de Ciencia y Tecnología
CSE	Computer and Information Science and Engineering [NSF Directorate]
DHHS	Department of Health and Human Services
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DVA	Department of Veterans Affairs
EPA	Environmental Protection Agency
FY	Fiscal year
GDP	Gross domestic product
GERD	Gross expenditures on R&D
HIV	Human immunodeficiency virus
ICRD	International cooperation in research and development
NASA	National Aeronautics and Space Administration
NATO	North American Treaty Organization
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NSB	National Science Board
NSF	U.S. National Science Foundation
OECD	Organisation for Economic Cooperation and Development
OMB	Office of Management and Budget
R&D	Research and development
RaDiUS	Research and Development in the United States [database]
SCERP	Southwest Center for Environmental Research and Policy

TRDP	Technical R&D Program
TTCP	Technical Cooperation Program
UNESCO	The United Nations Educational, Scientific, and Cultural Organization
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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## INTRODUCTION AND METHODOLOGY

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### INTRODUCTION

The U.S. government supports and participates in international cooperation in research and development (R&D). In fiscal year (FY) 1995, for example, the U.S. government spent \$3.3 billion in formal binational and multinational cooperative activities (Wagner, 1997), representing about 4 percent of the U.S. federal R&D budget. Since this amount represents formal cooperation—projects for which cooperation is a stated goal—the dollar amount understates the full extent of international scientific collaboration the U.S. government supports.

International activities are not conducted for their own sake—those of the U.S. government generally meet specific mission requirements or build scientific capabilities central to national interests. Accordingly, international activities are not budgeted separately or in a way that is easy to identify or track. Determining where these funds are being spent, with whom, under what conditions, and in which areas of science requires significant detective work that includes reviewing thousands of pieces of individual program, project, and award data contained with RAND's Research and Development in the United States (RaDiUS) database and obtained from government agencies, as well as talking to numerous government officials.

The White House Office of Science and Technology Policy (OSTP) asked RAND to assess the extent of R&D cooperation and the nature of cooperative R&D activities the U.S. government sponsors with Canada and Mexico. This project grew out of an earlier RAND project (Wagner, 1997) that identified U.S. government R&D spending on international activities around the world.

### CREATING THE DATA SET

A great deal of information on government R&D spending is electronically available through RAND's RaDiUS database.<sup>1</sup> RaDiUS is the first comprehensive, fully searchable data system that contains information on the approximately \$70 billion of annual spending the federal government classifies as "R&D," the Office of Manage-

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<sup>1</sup>RaDiUS can be accessed at <https://radius.rand.org>.



ment and Budget (OMB) defines it in Circular A-11.<sup>2</sup> RaDiUS contains information on federal government R&D activities derived from more than 500 different sources of budget or program data. RaDiUS is a full-text searchable database, and its records contain both budget and project information. We used this database in the first stage of data collection.

U.S. government agencies also provided information for this report. The governments of Mexico and Canada also provided assistance and information. In addition, a number of U.S. government officials and consultants knowledgeable about the R&D relationships with Canada and Mexico have provided important information and comments.

## Methodology for Developing the Data Set

Figure 1.1 shows the five steps taken to create the data for this inventory. Part one involved collecting data from official and primary data sources. The RaDiUS database was searched using an iterative search strategy. Searches were conducted on words (such as *Mexico* in conjunction with *collaboration*), on units of government (such as the National Aeronautics and Space Administration [NASA]), and on countries and continents (such as *Canada* or *North America*). Dozens of searches were run to capture all relevant programs, projects, and awards.

Part two involved examining and sorting the data and running additional searches, where needed. Once the full set of relevant activities was identified, the project descriptions and award abstracts were sorted, coded, and classified according to a range of characteristics described below.

Part three of the process involved consultations with federal funding experts and with staff at the OSTP to identify where additional data were needed. We then contacted government officials to ask for assistance in validating data obtained from RaDiUS and, if necessary, in identifying additional budget data. In some cases, supplementary data were not available from the agency.

Part four of the collection effort involved contacting officials in Mexico and Canada who could validate the information collected, as well as those who could provide

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<sup>2</sup>R&D is an OMB budget term applied within government agencies to define a specific form of federal investment activity. OMB defines R&D activities within the federal budget in Circular A-11 as activities falling within these general guidelines:

- **Basic research**—systematic study to gain knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind.
- **Applied research**—systematic study directed toward greater knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.
- **Development**—application of knowledge toward the production of useful materials, devices, and systems, or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

In FY95, this activity amounted to approximately \$70 billion. This inventory includes only activities federal agencies have classified as R&D. Joint scientific and technological projects, not counted as R&D, will be described later in this report.

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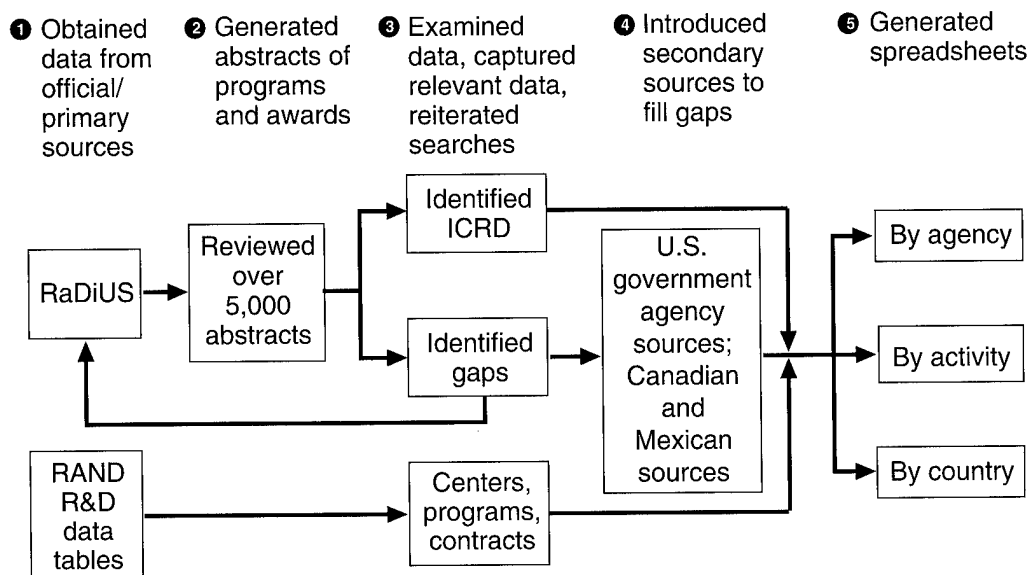


Figure 1.1—Method Used to Compile Data

additional information. Finally, the process involved compiling all the data collected from all sources, placing the data in spreadsheets, examining the data for duplications and obvious errors, and then analyzing the data set.

### Scope of the Data-Collection Effort

This inventory included any type of program-based R&D activity—projects or awards (contract, grant, or cooperative agreement)—that has, as *one of the principal purposes*, the sponsorship of international cooperation with Canada, Mexico, or both, or multinational cooperative projects in which Canada and Mexico are partners along with the United States and other nations. Projects descriptions that name a Canadian or Mexican collaborator and subject can be identified and categorized as formal, government-sponsored cooperation. Clearly, this inventory does not capture much of the international activity, coordination, and sharing that goes on at an informal level, since we limited the study to activities for which cooperation is a specific project goal.

When a project or award described international scientific or technical cooperation as a principal part of that activity, the *full average annual* budget authority for the relevant years was included in the inventory.<sup>3</sup> While this method may have led to overcounting in a limited number of cases, the alternatives were unworkable. Possible alternatives included (1) asking agency officials to report on the share of a project dedicated to R&D, a data point they usually do not have available; (2) contacting principal investigators directly and asking them to report on the extent of funding

<sup>3</sup>In many cases, the activities identified in this inventory were funded on a multiyear basis. In these cases, RaDiUS reports, and the project team counted, the average annual funding figure.

dedicated to international cooperation in research and development (ICRD), a Herculean task given the final data set of nearly 3,000 projects; or (3) having RAND staff make a judgment, an impossible task without additional information.

Cooperation is defined for the purposes of this study as federally supported activities in which a U.S. government-funded researcher is involved in a project with a foreign researcher, a foreign research institution, a multinational institution, or a multinational research project. Projects and awards that fell within this definition encompassed scientist-to-scientist collaboration and field research in which a scientist worked with a collaborator to gain access to a natural resource; research for a doctoral dissertation, when that activity was classified by the agency as R&D; and government agencies supporting the conduct of research through operational and technical support, again, where that activity is budgeted as R&D. The definition did not include activities for which a U.S. government official met briefly or shared data intermittently with counterparts from other countries—which would generally be considered “informal” cooperation.

Agencies that use contracts, grants, and cooperative agreements to conduct most or all of their R&D are the most fully represented in the RaDiUS database and therefore are the most fully represented in this inventory. When government money changes hands, records are made of the transactions, and the grant or contract recipient often provides a full description of the planned activities.<sup>4</sup> This is often referred to as extramural research. Agencies that sponsor extramural research include the U.S. National Science Foundation (NSF),<sup>5</sup> the U.S. Department of Health and Human Services (DHHS),<sup>6</sup> the U.S. Department of Agriculture, and the non-laboratory-based activities of the departments of Defense and Energy (DOD and DOE).

When the R&D is conducted within government laboratories—intramural research—spending is more difficult to track. While we made an effort to identify and characterize these activities, cooperative activities in these parts of the government may not be fully represented in this study. Identifying and collecting information on intramural research involved, first, using RaDiUS to locate federal agencies likely to contain these activities and, second, contacting the agencies to seek the information directly. Even though we made extensive efforts to contact agencies with program or laboratory-based activities, it was difficult at times to decouple the international activities from other activities going on in these agencies or laboratories. Agencies sponsoring this intramural activity include parts of NASA, the Environmental Protection Agency (EPA), the U.S. Agency for International Development (USAID), the National Institute of Standards and Technology (NIST) at the Department of Commerce (DOC), the DOD, the DOE, and the independent Smithsonian Institution.<sup>7</sup>

<sup>4</sup>This methodology will not capture activities for which international cooperation was established after the grant or contract was awarded.

<sup>5</sup>Close to 95 percent of NSF R&D funds leave the agency in the form of grants or contracts.

<sup>6</sup>Close to 80 percent of DHHS R&D funds leave the agency in the form of grants or contracts.

<sup>7</sup>The Smithsonian Institution is not a government agency. The institution, however, is unique in that it receives a direct line-item appropriation of R&D funds from the federal budget. These R&D funds are tracked and were considered in this study.

## Coding the Data Set

To create a useful database for analysis, the data records were classified using four main categories:

- by country, or, when researchers from more than two nations are involved or where a U.S.-funded researcher reported working with a multinational research organization, as a “multinational” activity
- by type of cooperation, in categories developed by RAND, for identifying the character of the cooperative projects or programs funded by the U.S. federal government (see Table 1.1)
- by fields of science or technology, using a list adapted by RAND from the National Science Board (NSB) list of areas of science and technology (see Table 1.2)
- by sponsoring agency.

For example, a project with Mexico on the synthesis and characterization of solid “superacids” would be classified first as “Mexico”; then as collaborative research, because it involved scientist-to-scientist collaboration between a U.S. and a Mexican institution; then as “chemistry,” the area of science; and finally as a project being funded by the NSF. Similar classifications were made of all the projects identified in the database.

**Table 1.1**  
**Types of Cooperative Activity Identified in the Course of the Study**

Collaboration	A principal purpose of the research activity is to sponsor international collaboration of the following types: a researcher funded by the U.S. government working jointly with a collaborator from another country, when a researcher funded by the U.S. government is conducting a research program that involves actively sharing information with another researcher conducting the experimental or observational research, or when a researcher is contributing to an international cooperative project
Conference	Either foreign or domestic—including symposia, workshops, or other official meetings in which scientists from around the world participate in a scientific or technical meeting to describe and share ongoing research
Database development	The U.S. government is sponsoring the creation of an international database of information being collected from sources worldwide, which will be available to researchers from around the world
Operational support	The U.S. government is funding the building, maintenance, and/or operation of an international research center designed specifically for the purposes of international collaboration in the United States or in a foreign country
Standards development	The U.S. government is sponsoring the development of a technical or scientific standard that will serve as the basis for future research, development, or production for practitioners around the world
Technology transfer	The U.S. government is actively seeking to transfer technology from a foreign country to the United States
Technical support	A U.S. government laboratory or a U.S. government-sponsored researcher is providing R&D results or other support to a foreign researcher or laboratory

**Table 1.2**  
**Fields of Science Used to Identify the Nature of ICRD**

Agricultural sciences	Demography	Oceanography
Anthropology	Earth sciences	Other earth sciences
Archaeology	Economics	Other engineering sciences
Atmospheric sciences	Environmental sciences	Other life sciences
Biology	Genetics	Other physical sciences
Biomedical sciences	Geography	Other social sciences
Biotechnology	Geology	Physics
Chemical engineering	Health	Plant biology
Chemistry	Materials sciences	
Computer engineering	Mathematics	

## STRENGTHS AND LIMITATIONS OF THIS APPROACH

The data collection technique used in this study has significant strengths. First, the data have been gathered from the “bottom up,” by identifying activities at the lower levels and aggregating up into programs, bureaus, and agencies. Second, this approach enabled consistent screening of the data using a single filter. This helped us ensure the comparability of data across agencies. Third, this approach has the advantage of identifying cooperative activities in actual operation, as opposed to cooperation proposed in international bilateral and multilateral cooperative agreements. Fourth, the method we used is transparent and reproducible. This allows trend analysis over time and across agencies.<sup>8</sup>

The approach used to conduct this inventory also has limitations. Some agencies do not compile or report data on activities at the project or award level. In these cases, the inventory includes program-based activities at higher aggregations, such as budget line items. The implication of this lack of detail for the full inventory is that the compiled data do not reflect the full spectrum of project-level activities being funded by the U.S. government. USAID, for example, reports data only at the budget line item, so no additional analysis or comparison of USAID activities is possible. The USAID budget line-item data are delineated by region, but that is the most detailed data we could find for USAID activities. When this inventory was made, USAID could not provide additional information on the types of R&D activities sponsored in these regions. The EPA also does not report detailed project-level activities. Some DOE and DOD laboratory-based activities may also be unreported.

<sup>8</sup>This is also the reason we used R&D instead of the larger set of activities that would be represented by the term *science and technology*.

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**R&D COOPERATION IN NORTH AMERICA**

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Over the past decade, in the wake of North American Free Trade Agreement reforms, interest in the health of the North America research enterprise has grown.<sup>1</sup> Shared environmental and agricultural problems, as well as common interests in public health, geosciences, and telecommunications have spurred a greater interest in North American scientific and technical cooperation. Accordingly, it is useful to take stock of this relationship to see where cooperation exists and to identify places where opportunities exist for additional cooperation. While North American scientific collaboration takes many forms, one place to start is with the extent to which U.S. government R&D funds are committed to projects with Canada, Mexico, or both. This study reports on findings of an inventory of U.S. government spending on R&D cooperation with Canada and Mexico.

**OVERVIEW**

The U.S. government funds cooperative R&D projects in North America or with North American partners. Since 1993, U.S. government agencies have spent more than \$100 million a year on projects involving cooperation with Canada and/or Mexico. The activities funded have focused primarily on common interests and problems in environmental, agricultural, and earth sciences, as well as on biomedical and genetic research. Formal collaboration puts Canada and Mexico among the U.S. government's top 10 binational R&D partners (Wagner, 1997, pp. 17–19).

Funds for collaborative activities with Canada and Mexico, with a few exceptions, are not set aside specifically for cooperation with these countries. Collaborative ventures arise in two broad ways: one, when a U.S. government agency determines that a joint project is in the interests of the mission needs of that agency, such as a U.S. Department of Agriculture (USDA) study of forest monitoring project at the borders, and two, when a U.S. government-funded researcher identifies a partner in Canada or Mexico with whom collaboration would be in the interests of a scientific inquiry, such as a comparison by university-based biomedical researchers of the efficacy of heart bypass surgery. The benefits of collaboration are determined at the program or researcher level and are generally based upon a need to access data or natural resources or otherwise to link to excellent research taking place in Canada or Mexico.

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<sup>1</sup>Trade among the United States, Canada, and Mexico has nearly doubled since NAFTA was instituted in 1994.

The U.S. government's R&D relationships with these two countries, while having common scientific interests, differs in character. Examination of the different projects being undertaken among the different parties and interviews with government officials in Canada and Mexico show that the R&D relationship with Canada has the quality of a partnership between equals. The scientific exchanges are reciprocal, active, and robust. There are few formal agreements to conduct scientific exchange. In contrast, the relationship with Mexico, while sound and growing, is not an equal exchange. The relationship is more formal (having less informal scientist-to-scientist exchange): There are more government-to-government agreements to engage in cooperative activities. Moreover, there are more one-way transfers of information and assistance from the United States to Mexico: Cooperation with Canada focuses on scientific or technical questions, but cooperative projects with Mexico focus more on specific problems, such as water pollution or land management. Moreover, while the United States has an active cooperative relationship with Canada in both defense and space R&D (the areas in which the United States spends the majority of its research funds), there is little of this type of activity with Mexico.

The differing character of the relationships between the United States and its North America neighbors reflects the relative commitment of each country to a science and technology infrastructure. Canada's economy allows that nation to invest 1.53 percent of gross domestic product (GDP) in R&D, a figure in keeping with the investments made by other industrialized economies. (The United States invests 2.54 percent of GDP in R&D, among the highest investments in the world.) In contrast, Mexico is only able to invest 0.2 percent of its GDP in R&D. Table 2.1 compares the sizes of the economies and the investment in R&D in each of the three North American countries.

Research shows that the products of Canadian science are among the best in the world in a number of fields. Despite its relatively small population, Canada publishes close to 5 percent of the world's scientific and technical papers.<sup>2</sup> Table 2.2

**Table 2.1**  
**National Investment in R&D in North American Countries**

1995 data	Canada	Mexico	United States
Total Population (million)	30	95	263
GDP(US\$ billion)	694	721	7,248
Gross expenditures on R&D (GERD), all sectors (US\$ billion)	9	0.9	184
GERD as a percentage of GDP	1.53	0.2	2.54
Government spending on R&D (US\$ billion)	2.4	0.8	69
Number of trained scientific and technical workers (science and engineering univer- sity degrees)	147,001	129,668	1,174,436

SOURCES: OECD (1998), NSF (1998), and UNESCO (1996).

<sup>2</sup>Twelve percent of these papers are coauthored with U.S. scientists. (NSB, 1998, Table 5-52.)

**Table 2.2**  
**Bibliometric Representation of the U.S. Science and Technology**  
**Relationship with Canada and Mexico**

1995 data	Canada	Mexico	United States
Total number of papers published	17,359	1,408	142,792
Share of world publications (percent)	4	0.04	33
Internationally coauthored papers (percent)	52	67	32
Percent of U.S. papers coauthored with . . .	41	35	
Number of Canadian papers with . . .		51	4,152
Number of Mexican papers with . . .	N/A		

SOURCES: NSB (1998); 1998 data from l'Observatoire des Sciences et des Technologies, University of Quebec.

shows the share of world science and technology papers published by each of the three countries. Although Mexico publishes only a small share of the world's science and technology papers, its research is heavily international: 67 percent of the papers Mexican scientists publish have foreign coauthors; in contrast, in the United States, only 32 percent of papers are internationally coauthored.

Up to 41 percent of Canada's internationally coauthored papers are written with U.S. coauthors. (NSB, 1998, Table 5-53.) This number outstrips the extent of U.S. government commitment to the U.S.-Canada science and technology relationship, which accounts for about 2 percent of U.S. government international R&D activities. The divergence between the number of coauthored papers and the amount of U.S. government commitment has several possible explanations: One is that coauthored papers arise more from multinational collaboration, while the 2-percent figure includes only binational activities. Secondly, the divergence may indicate the informality of the U.S.-Canada relationship, which also is not represented in the 2-percent figure. Indeed, in the process of identifying formal relationships, it became clear that the majority of cross-border relationships are informal—a great deal of cooperation with Canada is based on individual relationships between scientists. Canada is much more likely than Mexico to participate in international collaborative science projects involving other nations.

### Trinational Relationship

The trinational relationship in science and technology is small indeed: In 1997, the U.S. government funded 20 trinational projects, mostly through the Department of Education. Nevertheless, the number of projects funded by the U.S. government and conducted jointly among the three countries increased from 1993 to 1997. For 1993, we were only able to identify three projects involving researchers from the three countries. By 1997, there were 20 trinational projects, including the following:

- the International Research on Drug Abuse Epidemiology, sponsored in the United States by DHHS
- the Center for North American Studies, which develops institutional linkages with internationally recognized agricultural programs in Mexico and Canada, sponsored by USDA



- the North America Research Fellows Program: The Ecology and Evolution of Host Use, sponsored by the NSF
- Several projects involving institutional cooperation and student exchanges among U.S., Mexican, and Canadian institutions in such fields as agribusiness, international business, environmental technology, engineering, and marine policy.

### Location of Research

U.S. cooperative projects identified for this study are not necessarily conducted in Canada or Mexico. In fact, the majority of the funds likely support activities in the United States, with the results and data being shared with foreign counterparts. In some cases, of course, fieldwork requires U.S. scientists to visit Canada or Mexico, usually entailing direct collaboration with foreign counterparts. In addition, although there are no survey data on this, it appears that a good deal of the R&D funds committed to international cooperation with Canada and Mexico leverage R&D funds and resources in those countries. Moreover, based on reports from government officials, it appears that many of the projects funded by the U.S. government find matching commitments from foreign partners.<sup>3</sup>

### Other Areas of Cooperation

In addition to the R&D projects reported in this study, the United States also participates in a number of scientific and technical projects with Canada and Mexico that are not classified in the U.S. budget as R&D. These larger scientific activities include environmental projects on the borders, particularly on the border between the United States and Mexico. Also not counted as R&D are some mapping and forestry projects that are funded separately by participating nations, which share the final results. Information exchanges in meteorology and metrology also are not counted as R&D. Some water projects, funded in the United States by the states bordering Mexico and Canada, are conducted cooperatively with Canada and Mexico. The dollar figures for these non-R&D and state projects are not included in this report. Nevertheless, we estimate that total U.S. spending for these larger scientific activities would likely equal or surpass the amount being spent on cooperative R&D activities.

This study also does not account for the extent to which the U.S. private sector collaborates in R&D with counterparts in Mexico or Canada. Data on private-sector R&D activities are difficult to obtain: Private firms do not readily share information on internal R&D activities. Nevertheless, governments track private-sector R&D investment patterns. These data provide gross indicators of the extent of interaction. In 1995, close to 7.5 percent of R&D U.S. affiliates conducted abroad took place in Canada. This accounts for as much as \$843 million in U.S. investment in Canada.

<sup>3</sup>A case study of cooperative research in earthquake sciences and seismology, detailed in Wagner (1997), pp. 36–37, found that the U.S. government was leveraging international cooperative R&D dollars one-for-one on average with matching funds or resources from foreign partners.

(Publication data indicate that much of this investment is in pharmaceuticals.) In turn, Canadian affiliates spending R&D funds in the U.S. account for 15 percent of foreign R&D investments in the United States in 1994, about \$1.3 billion in R&D investment. (Organisation for Economic Cooperation and Development [OECD], 1998, pp. 31 and 34.) While this cross investment does not necessarily involve scientist-to-scientist collaboration, one can assume that some collaboration is taking place. If even 4 percent of these activities involve U.S.-Canada collaboration in R&D, the total would be \$80 million—more than the U.S. government is spending per year on binational collaboration with Canada. According to knowledgeable experts, private, collaborative R&D with Mexico is very small.

### U.S. GOVERNMENT R&D RELATIONS WITH NORTH AMERICAN PARTNERS—A COMPARISON<sup>4</sup>

From 1993 through 1997,<sup>5</sup> U.S. government spending on cooperative R&D projects with Canada, not including defense and space research, averaged more than \$60 million per year, shared among more than 330 projects.<sup>6</sup> Cooperative R&D activities with Mexico during this time averaged about \$25 million per year spent among, coincidentally, the same number of projects. Relative to the sizes of their economies and their own federal R&D spending, Mexico benefits more than Canada does from the relationship with the United States.<sup>7</sup> This is also true when the number of researchers in each country is examined. Averaged across Canada's 77,000 researchers, U.S. funding is low (\$790 per researcher) compared to funding averaged across Mexico's 14,000 researchers (\$1,785 per researcher).<sup>8</sup>

Cooperation between U.S. government-funded researchers and their Canadian counterparts has been stable in terms of dollars over the five years studied for this project; during the same period, cooperation with Mexico has been growing. The total number of cooperative projects with the two countries has also grown from year to year. Even while the number of projects increased, funding did not rise significantly, suggesting that the average amount of money per project has gone down. This is likely due to the greater role of the NSF in funding international projects—NSF grants tend to be numerous but smaller than those of other government agencies.

<sup>4</sup>Data cited throughout the rest of the report are from the data set developed for the project unless otherwise noted.

<sup>5</sup>The funding during these years was examined according to the fiscal year calendar used by the U.S. federal government. The fiscal year runs from October 1 of any given year to September 30 of the next year.

<sup>6</sup>The total for cooperation with Canada, to be comparable with Mexico, does not include cooperation in defense or in space science. Nevertheless, the United States has a robust R&D relationship with Canada in these two areas, amounting to hundreds of millions of dollars.

<sup>7</sup>The GDP of both countries is similar (purchasing power parity): \$658 billion for Canada and \$694 billion for Mexico. For every dollar that the Canadian government spends (overall) on R&D, the Mexican government spends \$0.37. For every dollar that the United States contributes to cooperative activities with Canada, the United States contributes \$0.50 to Mexico, thus providing a relative benefit to Mexico.

<sup>8</sup>The data on numbers of researchers (university graduates) in Canada and Mexico (in 1995) were obtained from OECD (1997), Table 10.

Different styles of partnership mark the U.S. R&D relationships with Canada and Mexico. The relationship with Canada crosses a broad spectrum of scientific and technical questions, including space and defense—the fields of research in which the U.S. government spends the majority of its R&D funds.<sup>9</sup> Many of the cooperative projects with Canada, both binational and multinational, would be considered “big science” projects—for example, the International Space Station and the defense-related Technical Cooperation Program (TTCP). TTCP participants include the United States, Canada, and Australia, with cumulative funding at more than \$100 million per year; according to a Canadian government official, Canada participates in about 60 percent of the TTCP activities, or approximately \$60 million.

In contrast, projects with Mexico are more likely to be “small science” projects in earth sciences or biomedical cooperation. Within these areas, the R&D is generally conducted to help address problems in Mexico. Research on the health effects of pollution or providing clean water are examples of this type of research. Very little cooperative activity with Mexico focuses on space or defense.

### **Collaborative Research and Technical Support**

The majority of U.S. projects identified for this study with both Canada and Mexico have been collaborative—they involve researchers working together on a common scientific problem (see Figure 2.1). This has been truer for Canada, where 90 percent of all joint activities involve collaboration on a scientific or technical problem, compared to 71 percent in the case of Mexico.<sup>10</sup> Collaborative projects with Canada include a diversity of approaches and subjects, such as

- development of a large-capacity, lithium ion space cell and battery, sponsored on the U.S. side by DOD
- a bypass angioplasty revascularization investigation, sponsored on the U.S. side by DHHS and the National Institutes of Health (NIH)
- measurement of muscle strengths and abilities to perform activities of daily living in patients with amyotrophic lateral sclerosis (ALS), sponsored on the U.S. side by the Department of Veterans Affairs (DVA)
- early polar cap observatory, sponsored on the U.S. side by the NSF.

Only 10 percent of the U.S. federal dollars spent on cooperation with Canada fall into other categories, such as database development, technical support, or standards development.

<sup>9</sup>The R&D budgets of the DOD and NASA together account for nearly 63 percent of the federal R&D budget appropriation (OMB data).

<sup>10</sup>The Canadian projects include activities for which the subject of the research is primarily about Canada or in which a U.S. researcher is using data obtained from Canada. While it is not clear that these types of projects involve direct collaboration, they are included as such because they generally involve, at the least, information sharing.

### US-Mexico and US-Canada R&D Relationship

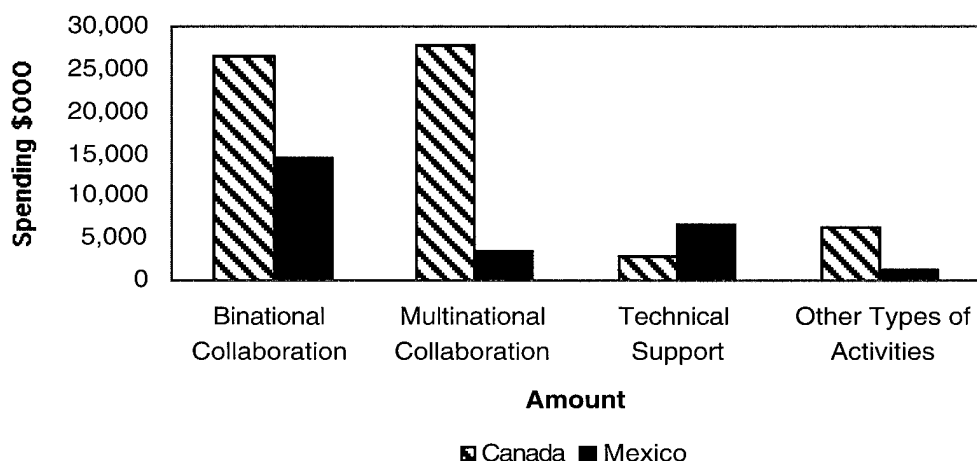


Figure 2.1—A Comparison of the Types of U.S. R&D Cooperation with Canada and Mexico

Within the scope of collaborative activities with Canada, more than half of the projects are multinational. Multinational projects include those the International Energy Agency sponsors to support joint research on energy projects, such as Energy Conservation and Emissions Reduction in Combustion, a three-nation project involving the United States, Canada, and the United Kingdom.

Collaboration with Mexico grew over the five years studied. A majority of projects being conducted between U.S. and Mexican counterparts are collaborative; such projects account for a growing share of the cooperation between the United States and Mexico. Collaborative projects include such activities as

- local ecological knowledge of common-pool resources in Campeche, Mexico, sponsored by the NSF
- improving community access to transborder environmental information in the San Diego–Tijuana region, sponsored by the EPA
- first stage aggregation of maquiladora plants by state and Standard Industrial Code and identification of waste streams associated with the production process by plant type, sponsored on the U.S. side by DOE.

In contrast to Canada, Mexico receives significant U.S. government technical R&D support. Technical support makes up 25 percent of funds the United States commits to cooperative projects with Mexico, compared to 5 percent to those with Canada. Technical support projects with Mexico include such activities as

- development of biological control techniques for management of the pepper weevil, sponsored by USDA

- renewable energy technical assistance and educational support in Mexico, sponsored by DOE
- Global Positioning System–based measurement system development and deployment in Mexico, sponsored by NASA.

### **Areas of Scientific and Technical Cooperation**

Ranging across most areas of science and technology, cooperation in North America still tends to focus on global environmental and health problems. In a previous study of cooperation in science worldwide, space, earth sciences, and biomedicine were the most prominent areas of international cooperation between the United States and its foreign counterparts. (Wagner, 1997, p. 19.) The same is true in North America, but most particularly with Canada, where the binational relationship is marked by collaboration in defense, space, biomedicine, and earth sciences. This follows a pattern of cooperation that the United States has with many developed countries. Cooperation with Mexico, at least for “small science” areas, is also characterized by spending R&D money on biomedical (25 percent), environmental (18 percent), and geological cooperation (9 percent). Mexico, however, does not participate in any significant way in binational or multinational space or defense sciences.

The areas of science that mark the U.S. relationship with Canada and Mexico have changed over the five years studied. In 1993, the lead areas of scientific cooperation with Canada were in biomedical, atmospheric, and earth sciences. Top areas with Mexico also included earth and biomedical sciences, as well as geology. By 1997, biomedicine had displaced atmospheric sciences from the top three areas of scientific cooperation between the United States and Canada. Atmospheric sciences dropped considerably as an area of cooperation over the five-year period. In the case of Mexico, environmental sciences joined the top three areas of cooperative research between 1993 and 1997, knocking out earth sciences, which also dropped over time. The largest areas of growth over the five years between the United States and Canada were in the areas of earth sciences, biotechnology, and geology. Areas of increase in cooperation with Mexico were environmental science, chemistry, agriculture, and economics. Areas of decline with both countries included engineering sciences, particularly chemical engineering and materials.

### **U.S. Government Agencies Supporting Cooperation**

Different clusters of U.S. government agencies sponsor cooperation with Canada and Mexico. Both DHHS and DOE are among the top funders of cooperative research with Canada and Mexico. Differing patterns are principally around space and defense research, with NASA and DOD being among the lead agencies working with Canada. In comparison, in dollar terms, the lead agencies sponsoring cooperative R&D with Mexico are DOE, NSF, and DHHS. In terms of the number of cooperative projects, NSF funds the largest number of projects with both countries. However, in dollar terms, NSF-sponsored projects involving Canadian researchers are funded at three times as much as those with Mexico.

As shown in Table 2.3, of the U.S. government agencies sponsoring collaboration with Canada, NASA has been the source of the largest number of joint papers with Canadian government partners; in 1995, 21 papers resulted from this relationship. (NASA also appears among the top 50 foreign coauthoring institutions for papers published by Canadian firms, with two papers in 1995.) Analysis of publication patterns also indicates that USDA, the DOC's National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS) have active collaborations with Canadian counterparts that result in joint papers. Notwithstanding the growth in joint papers between NOAA and Canada, these activities most likely do not result from R&D activities but from sharing data obtained from operational data collection.

## MECHANISMS FOR CONDUCTING R&D WITH FOREIGN PARTNERS

Binational collaborative projects funded by the U.S. government are carried out through a series of mechanisms that range from grants and contracts to the funding of research centers. In addition, international science and technology agreements facilitate the conduct and funding of research. This section describes funding mechanisms and international agreements.

### Grants, Contracts, and Cooperative Agreements

The majority of government-funded R&D—between 50 and 90 percent, depending upon the agency—is performed under government contract or grant and takes place in laboratories or other research centers outside of government facilities. Contractors and grantees tend to be in the private and academic sectors; thus, private or academic researchers conduct the majority of federally supported international cooperation. These activities are funded in five ways:

1. through research programs, such as projects within NASA labs
2. through awards (contracts, grants, and cooperative agreements)
3. by funding and maintaining the operation of centers for international research, such as the National Nuclear Data Center, a DOE center responsible for data

**Table 2.3**  
**Number of Joint Papers Published between U.S. Government**  
**Laboratories and Canadian Government Counterparts**

U.S. Government Agency or Laboratory	1993	1994	1995
NASA	12	23	21
USDA, Agricultural Research Service	10	4	18
NOAA	11	9	15
USGS	6	10	16
Brookhaven National Laboratory (DOE)	6	4	5
Argonne National Laboratory (DOE)	5	6	5
EPA	5	3	5
Woods Hole Oceanographic Institute	6	3	5

SOURCE: 1998 data from l'Observatoire des Sciences et des Technologies.

compilation, evaluation, and information services for basic and applied scientists in the United States and Canada

4. through funds provided or reimbursed by foreign countries, such as funds paid to the CDC to conduct infectious disease testing side by side with Mexican research scientists
5. through funds paid in remission of debt, such as the debt-for-science swap carried on with Mexico.

All of these mechanisms have been used to fund cooperative research with Mexico; activities with Canada have not included debt-for-science swaps.

### **Disbursements Through Centers**

Several research centers disperse funds from the U.S. government, the Canadian or Mexican governments, or some combination. Sometimes, private-sector funds are also disbursed through centers. Centers providing funds for U.S.-Mexican cooperation in science and technology include the U.S.-Mexico Foundation for Science, the Southwest Center for Environmental Research and Policy, and Sandia's Mexico Program. An example of a center sponsoring cooperative activities between the United States and Canada includes the USDA Center for North American Studies, which is responsible for developing cooperative research programs with Mexico and Canada to investigate the priority issues related to growing North American trade in agricultural and food products.

### **International Agreements**

The U.S. government has signed numerous international science and technology agreements with both Canada and Mexico. In 1972, the United States signed a framework or "umbrella" science and technology agreement with Mexico that is still in effect with no set termination date.<sup>11</sup> The United States does not have an umbrella science and technology agreement with Canada.

The Canadian government has signed as many as 115 agreements with U.S. entities, including U.S. federal agencies; states; and associations, such as the American Association for the Advancement of Science. (Department of Foreign Affairs and International Trade, 1997.) In addition, the United States and Canada are signatories to a number of multinational cooperative agreements, including 15 such agreements Canada noted in a recent report. Of these, seven agreements focus on cooperation among the United States, Canada, and Mexico; these agreements include such subjects as conservation of wildlife habitats, environmental education and training

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<sup>11</sup>The U.S. government, through the Department of State, signs "umbrella" or "framework" agreements with specific countries when it appears to be in the mutual interest of both parties to do so. These agreements outline broad subjects for cooperation and contain provisions for protection of intellectual property. No U.S. government funding is committed as a result of signing these umbrella agreements. A list of the 33 countries with which the United States currently maintains agreements is available at [http://www.state.gov/www/global/oes/science/fs-s&t\\_umbr\\_agrmts\\_990421.html](http://www.state.gov/www/global/oes/science/fs-s&t_umbr_agrmts_990421.html).

activities, and technical standards. (Department of Foreign Affairs and International Trade, 1997.)

The Mexican government agency Consejo Nacional de Ciencia y Tecnología (CONACYT) reports that it has signed agreements with U.S. government agencies, such as NSF, NIH, and NIST, to encourage scientific collaboration. In an agreement with NSF, for example, such activities as researcher mobility and programs in computer sciences and information exchange take place. Three of the NSF-CONACYT agreements encourage U.S.-Mexico applications to NSF. As a result, around 60 applications are received annually, and approximately 35 to 40 are approved. Selection is based on the NSF peer-review process, with both NSF and CONACYT participating in the decisionmaking process.

The agreement signed between CONACYT and the NIH supports postdoctoral programs, as well as extended research visits, workshops, and information exchanges. To date, the postdoctoral fellowships awarded through the agreement have generated some cooperative projects funded through the supporting agency.<sup>12</sup>

## OUTLOOK FOR NORTH AMERICAN COOPERATION

Collaboration in science and technology is influenced by many factors, among them a country's ability to invest in science and technology, its levels of scientific infrastructure and expertise, and its cultural values and the economic goals. The locations of natural resources, geological phenomena, and anthropological sites also influence the patterns in which countries collaborate with each other. Social and economic influences create different balances between supply and demand for scientific knowledge in each country. Choices about when and with whom to cooperate will be influenced by all these factors, in different degrees by different nations. Geographic proximity may be a factor for forming similar patterns but probably to a lesser degree than the level of development and national infrastructure.

Cooperation among the North American countries in science and technology can be expected to grow over the next decade. Canada and Mexico continue to make investments in their national science and technology enterprises in ways that provide opportunities for enhanced cooperation. Both countries have increased GERD over the past decade. In addition, the number of university-trained R&D personnel in each country has risen. The OECD reports that Mexico's GERD has risen to 5.7 million pesos in 1995 from 2.7 million pesos in 1993. The number of Mexico's R&D personnel has risen to 33,000 in 1995 from 26,000 in 1993. Similarly, Canada's GERD has risen to \$14 million Canadian from \$11.4 million in 1993. R&D personnel rose to 130,000 in 1995 from 122,000 in 1993. (OECD, 1998.)

Despite a growing commitment to science and technology, the U.S. relationships with Canada and Mexico will continue to differ in character. Canada's scientific culture is closer to that of the United States. Canada is among the leading scientific nations in the world. National investment and publication patterns show Canada,

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<sup>12</sup>In general, funds for these types of fellowships are not budgeted as R&D funds.



like other leading nations, moving away from the “older” sciences, such as physics and chemistry, and more toward modern life-science disciplines. (Okubo et al., 1992, p. 333.) Table 2.4 shows the areas of scientific specialization of the North American countries based upon publication data. Canada’s profile more closely matches that of the United States.

Mexico’s patterns of international collaboration mainly track with those of India, Brazil, Argentina, and Venezuela, countries that are developing but that also have scientific infrastructures and globally active industrial sectors. (Department of Foreign Affairs and International Trade, 1997, p. 342.) Analysis of publication patterns shows that Mexican scientists are more likely to publish with Brazilian and Venezuelan scientists than they are with U.S. partners, perhaps because of a similarity among those countries in language and culture. (Department of Foreign Affairs and International Trade, 1997, p. 342.) Moreover, these countries continue to invest significant R&D funds in older sciences, such as physics and chemistry, which support a growing industrial base.

## OPPORTUNITIES FOR ENHANCED COOPERATION

Although the relationships among the three North American countries will differ based upon the nature of the science and technology infrastructure in each country, there are opportunities for enhanced cooperation between the United States and its neighbors and among the three nations. With Mexico, in particular, opportunities for greater U.S.-Mexico scientist-to-scientist cooperation are evident. These are described briefly below:

1. Areas defined for this study as “research about Mexico” are ripe for increased collaboration between the United States and Mexico. These covered research projects in which it appeared that a U.S. researcher was working in Mexico without an active partnership. These areas include archaeology, geology, biomedicine, anthropology, mapping, and earth sciences. In addition, a good deal of research is taking place in the Gulf of Mexico in which Mexico is not a partner. U.S. government agencies funding research about Mexico can encourage principal investigators to find a Mexican partner early in the research process.
2. Education and training is another area in which U.S. partnerships with Mexican scientists can flourish. Bibliometric analysis shows that patterns of international collaboration in publications are surprisingly stable from year to year. (Department of Foreign Affairs and International Trade, 1997, p. 337.) This indicates that the tendency of a scientist to collaborate is established over a long period and does not change within a year or two. Having researchers meet and work together early in their careers will influence the extent of cooperation in the future. Thus, increased opportunities for joint education and training activities will likely enhance true collaborative activities between U.S. and Mexican researchers.
3. There is little U.S.-Mexico collaboration in the higher-technology areas, such as electronics and communications, in which both countries also have shared inter-

**Table 2.4**  
**Areas of Scientific Specialization, as Revealed by Publication Counts**

1995 Data	Canada	Mexico	United States
Field with largest number of national articles	Clinical medicine	Physics	Clinical medicine
Field with second largest number of articles	Biomedical research	Clinical medicine	Biomedical research
Field with third largest number of articles	Biology	Biomedical research	Physics
Field with fourth largest number of articles	Chemistry	Biology	Chemistry

SOURCE: NSB (1998), Table 5-51.

ests. Moreover, the bulk of the projects being conducted focus on applied R&D, with little being done in basic sciences, such as chemistry, physics, and space science. Given that Mexican scientists have shown international publication strength in these areas of science (Russell, 1998, pp. 113–124),<sup>13</sup> these may be opportunities for the NSF and CONACYT to encourage cooperation.

With Canada, too, opportunities for enhanced cooperation emerge from joint interests of the United States and Canada in natural and scientific resources. Interest in forest monitoring has grown in both the United States and Canada as environmental research has become a priority for these countries. The United States and Canada share ecosystem resources on the border that require monitoring and tending. Canada has been aggressive about using remote sensing technology to monitor forests.<sup>14</sup> Cooperation in collection and analysis of both remote sensing and in situ forest monitoring would benefit both countries.

Trinational activities present the most promising area for enhanced cooperation. U.S. government funding for trinational activities amounts to about \$2 million per year. Yet, the three countries have a number of environmental, agricultural, health, and space interests in common. In particular, oceans, forests, water, and atmosphere offer research opportunities for pan-North American collaboration.

Identifying these opportunities may require a more strategic approach to decision-making about some areas of U.S. government-funded scientific research. There is often a tension in R&D funding between bottom-up, merit-based research funding and top-down, mission-oriented research. The challenge here is how to mobilize resources toward the support of North American science, while allowing researchers to retain autonomy, and to give scientists a role in decisionmaking.

One way to accommodate strategic goals and scientific excellence is to provide funding through a center, such as the U.S.-Mexico Science and Technology Foundation. Funds provided to a group like this could have a strategic focus on specific

<sup>13</sup>Russell reports that Mexican scientists have made important contributions to international science in the areas of biomedicine, chemistry, physics, astronomy and astrophysics, and geosciences (Russell, 1998, p. 115).

<sup>14</sup>RAND research.

issues and problems, while still allowing a peer-review committee to determine what projects should be funded and who should receive support. Establishing a three-way science and technology foundation or commission may allow each nation to provide support to North American research issues. Similarly, a special event, such as a North American science and technology week, may provide an opportunity to link researchers together.

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**AN OVERVIEW OF FINDINGS: U.S.-CANADA COOPERATION**

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In fiscal years 1993 through 1997, the U.S. federal government spent on average \$62 million per year (not including joint projects with NASA and DOD<sup>1</sup>) on cooperative R&D with Canada. This is about 19 percent of the \$3.3 billion that the U.S. government spends on international cooperation in R&D. Cooperative activities between the United States and Canada include formal binational and multinational projects, most of which are represented in the data reported here. This report does not quantify the informal contacts between U.S. and Canadian scientists, which, according to oral testimony, are an active part of the binational relationship.

Binational activities with Canada include cooperation on both the scientist-to-scientist and institutional levels. Other activities that make up the cooperative relationship include U.S.-conducted studies focusing on Canada—which we have termed “research about Canada.” Cooperative activities also include conferences, database development, operational support for international laboratories, technology transfer, and standards development. Cooperation takes place in a number of scientific and technical areas, such as biomedicine, earth sciences, and environmental sciences. The DHHS and the NSF lead some 11 agencies that fund cooperation with Canada.

#### **THE CHARACTER OF U.S. GOVERNMENT R&D WITH CANADA**

The U.S.-Canadian relationship in R&D has been marked by an increase in the number of projects and a slight decrease in the total funds spent on these activities over the five years studied (see Figure 3.1). Funding levels fluctuated from \$61.1 million in 1993 to a high of \$64.6 million in FY94, then dropped off in FY97 to \$60.2 million. Conversely, the total number of projects funded by the U.S. government increased over this time, to over 400 in FY97 from about 215 in FY93.

A range of activities mark formal R&D cooperation:

1. **Collaborative research**—On average, over the period studied, binational scientist-to-scientist collaboration accounted for 61 percent of the total number of projects

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<sup>1</sup>Canada participates in a number of NASA and DOD projects. Because of the nature of these projects, R&D project funding is often very large and would skew the data if presented together. We present the findings separately in this chapter.

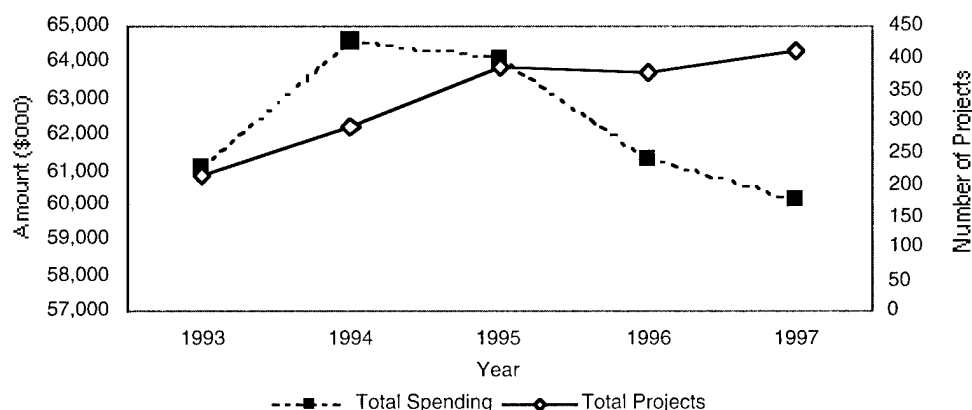


Figure 3.1—U.S.-Canada Cooperative Research: Number of Projects and Spending

undertaken and 43 percent of the funding, with the number of projects steadily rising and the amount of funding declining somewhat. Research about Canada, a type of collaborative research in which most of the activity appears to be involved in studying Canada or using Canadian data, has been steadily growing over the years, representing as much as 20 percent of the projects undertaken in FY97 and 9 percent of total funding in that year, up from 14 percent of projects and 4 percent of funding in FY93.

2. **Multinational collaboration**—Even more than binational research, the United States and Canada collaborate in multinational activities. On average, 45 percent of the funding and 15 percent of the projects involve the United States and Canada in multinational projects.
3. **Trinational collaboration**—Trinational efforts among the United States, Canada, and Mexico accounted for an average 3 percent of the funding and 4 percent of the projects undertaken but has been growing steadily.
4. **Other cooperative activities**—Such activities as database development, standards development, operational support, conferences, and technology transfer accounted, on average, for 20 percent of the projects undertaken but claimed only 8 percent of funding.

Joint activities in biomedical sciences account for 49 percent, the largest percentage of projects being conducted cooperatively between the United States and Canada; followed by earth sciences, which accounted for 18 percent; and other social sciences, geology, environmental sciences, and biotechnology, which together accounted for an additional 28 percent. DHHS, NSF, DOE, and DOC together commit roughly 90 percent of the funds contributed to the binational relationship.

### COLLABORATIVE RESEARCH WITH CANADA, 1993–1997

Among the different activities being funded, the overwhelming majority of funds are spent on collaborative research. About 45 percent of collaboration is multinational,

and the remainder involves binational collaboration between U.S. and Canadian scientists.

Collaborative research grew considerably during the period studied, increasing to 268 projects by 1997 from 126 projects in 1993, up 112 percent, although funding for these activities fluctuated somewhat during the period (see Figure 3.2).

An increasing share of U.S. government funding for collaborative R&D with Canada centers around natural or social phenomena in Canada but may be conducted solely by U.S. scientists. In 1993, projects in which researchers conducted research about Canada accounted for close to 14 percent of all projects undertaken. By 1997, 22 percent of all projects fell in this area. Canada's excellent data sets may account for this trend. Examples of these types of projects include the role of the government in rural housing (a comparison between New England and eastern Canadian policies) and the effects of electoral systems on legislator-constituency relations in Canada.

Funding for research about Canada has fluctuated but, overall, has increased even more dramatically than the number of projects, from 4 percent of the total in 1993, to 14 percent in 1997. Figure 3.3 outlines the increase in the number of projects and funding for research about Canada.

Database development, conferences, operational support, standards development, and technology transfer together have accounted for one-fifth of all projects undertaken with Canada and between 7 and 11 percent of all funding. Notably, joint conferences increased to 50 in 1997 from 31 in 1993.

### **Fields of Science Represented in Binational Collaboration**

Biomedical science, which accounts for as much as 37 percent of the total number of joint projects, is the most common subject of binational collaboration with U.S. government funding (see Figures 3.4 and 3.5). This is partly because the Canadian health system maintains an excellent database that provides epidemiological and longitudinal data that are valuable to health researchers. Cooperation in this area has also increased at a significant rate over the time studied. A marked increase in DVA-sponsored collaborative activities helps account for the increase.

Earth sciences account for the second most common area of cooperative activity between the United States and Canada. Table 3.1 lists percentage of funds expended in each area of science in each of the years examined. Funding for the areas of science represented in the binational relationship varied somewhat over time and as part of the total. Notable increases can be seen in the areas of earth sciences (which accounts for almost 30 percent of funding by 1997, up from 7 percent in 1993) and geology (which increases its share to 5.8 percent in 1997, from 1.7 percent in 1993).

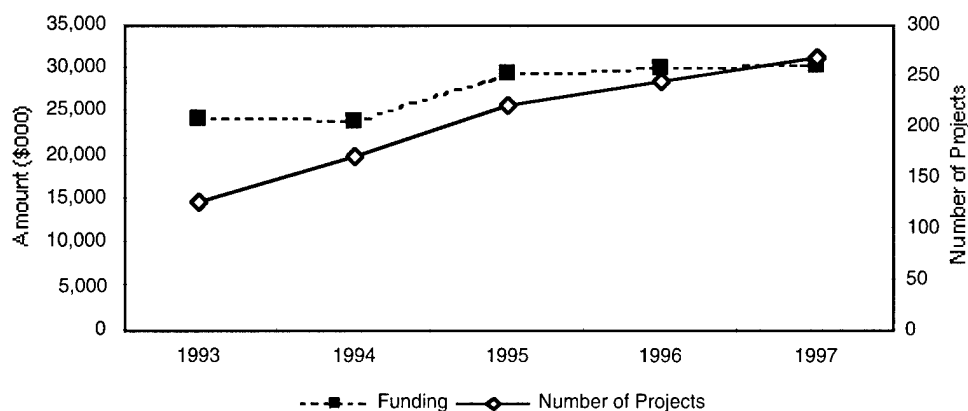


Figure 3.2—Number of Projects and Spending on Collaborative Research

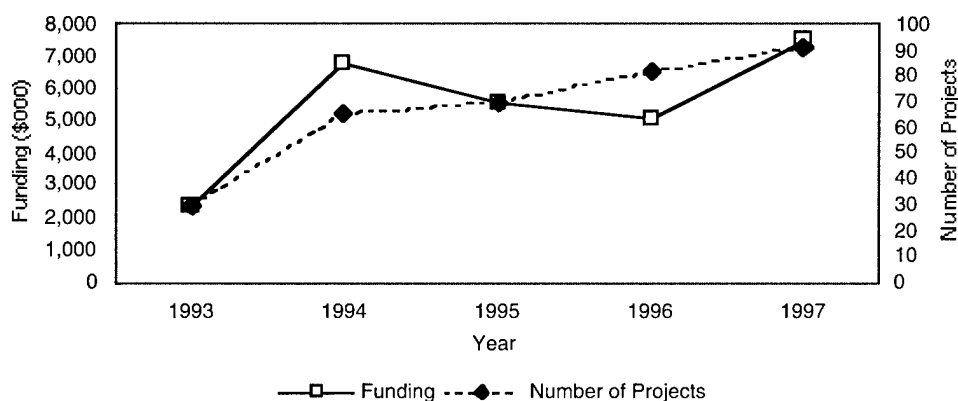


Figure 3.3—Number of Projects and Funding for Research About Canada

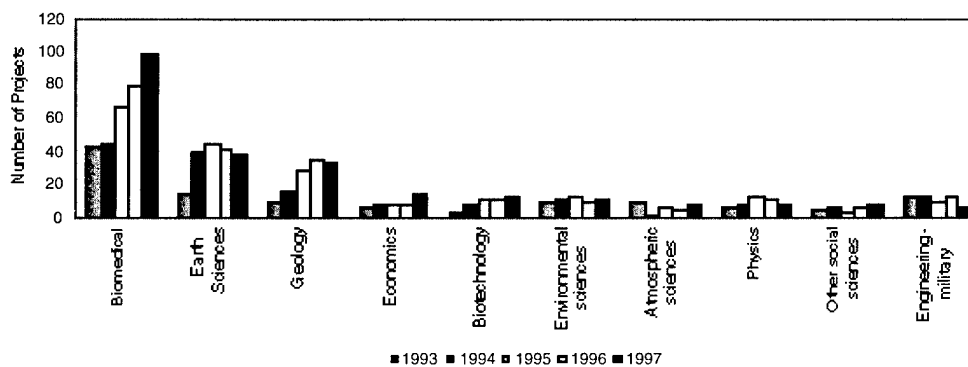


Figure 3.4—Number of Collaborative Projects by Area of Science

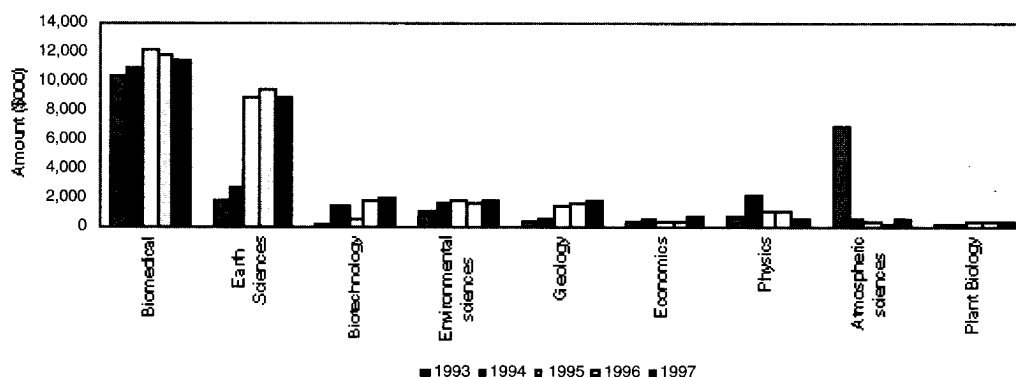


Figure 3.5—Funding for Collaborative Projects by Area of Science

Table 3.1  
Funding by Areas of Science, 1993–1997 as a Percentage of Total Funding

		1993	1994	1995	1996	1997
Biomedical	↓	42.6	46.3	41.9	39.3	37.8
Earth sciences	↑	7.1	11.3	30.7	31.1	29.9
Biotechnology	↑	0.3	5.9	1.8	5.8	6.5
Environmental science	↑	4.5	6.9	6.2	5.3	6.3
Geology	↑	1.7	2.5	4.8	5.5	5.8
Economics	↑	1.6	2.5	1.3	1.2	2.6
Physics	↓	3.1	8.7	3.7	3.6	2.1
Atmospheric Sciences	↓	29.0	2.0	1.4	0.9	2.0
Plant Biology	↑	0.8	0.7	1.4	1.4	1.4
Engineering Sciences	↑	0.3	7.5	0.1	0.4	0.9
Computer engineering	↑	0.7	0.0	0.6	0.8	0.8
Engineering, military	↓	2.5	2.5	1.7	1.7	0.8
Other social sciences	↓	1.6	0.9	2.7	0.7	0.8
Chemical engineering	↓	2.0	0.0	0.2	0.3	0.4
Other life sciences	—	0.2	0.9	0.3	0.5	0.4
Demography	↑	0.0	0.6	0.2	0.5	0.3
Materials	↓	1.3	0.0	0.1	0.0	0.3
Agricultural sciences	↓	0.6	0.0	0.6	0.3	0.3
Mathematics	↑	0.0	0.3	0.3	0.2	0.2
Biology	↑	0.0	0.0	0.1	0.5	0.2

NOTE: Arrows indicate funding movement between 1993 and 1997.

### Government Agencies Supporting U.S.-Canada Collaboration

Ten U.S. government agencies support binational R&D collaboration with Canada. Seven of them consistently funded collaborative projects over the period studied (Figures 3.6 and 3.7). DHHS leads in total funding but is third behind the NSF and the DVA in total number of projects sponsored. Other agencies providing consistent funding include the DOD, NASA, DOE, and DOC.



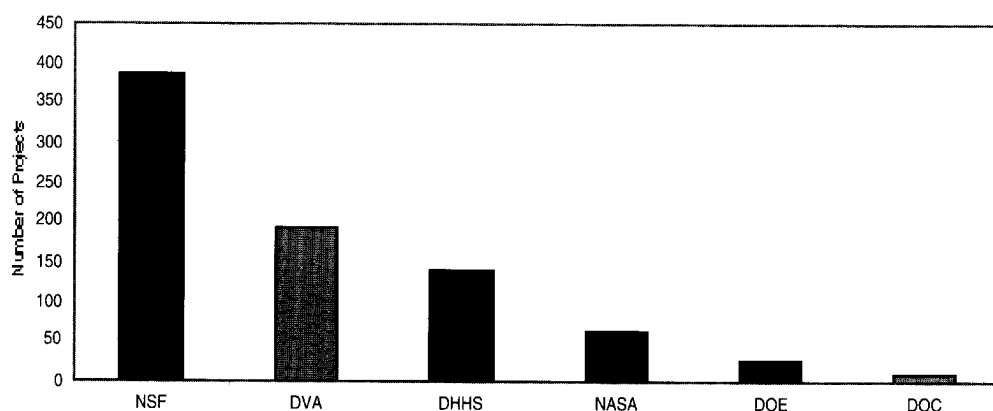


Figure 3.6—Number of Collaborative Projects by Agency

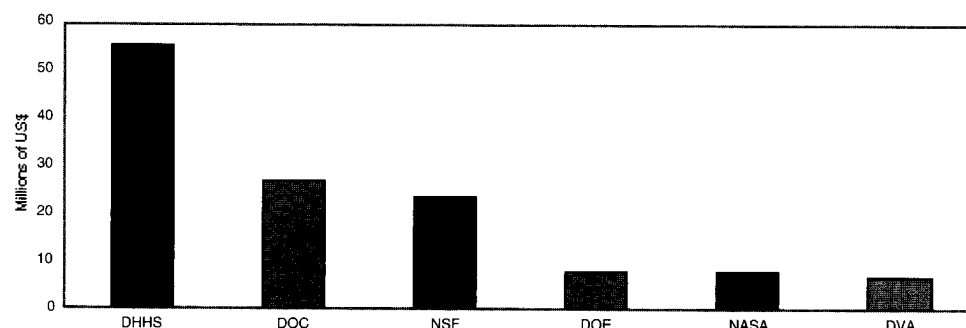


Figure 3.7—Funding for Collaborative Projects by Agency

### Department of Health and Human Services

During the period studied, DHHS accounted for about 40 percent of funding for U.S.-Canadian binational collaborative activities (see Figure 3.8). The average funding for a DHHS project with Canada is over \$385,000. DHHS-funded projects are, for the most part, collaborations between institutions—such as CDC or the NIH and their Canadian counterparts. These projects are classified within the fields of biomedical sciences and earth sciences. The largest amounts of funds spent on DHHS collaborative activities with Canada have come through the NIH.

Many of the projects undertaken involve patient participation in hospitals and clinics in Canada and the United States, as well as population-based studies using subjects in both countries. For example, the Heritage Study, which is looking at genetics, exercise, and risk factors, was undertaken by a consortium of laboratories from five different U.S. and Canadian institutions that recruit, test, exercise-train, and retest about 650 subjects. Another example is the Bypass Angioplasty Revascularization

Investigation clinical center at the University of Alabama Medical Center, a collaborative clinical trial comparing the efficacy of bypass surgery. The effort took place in 14 primary and 4 satellite centers in the United States and Canada.

### National Science Foundation

The NSF funded binational collaborative scientific activities with Canada at an increasing rate during the five years studied. The number of binational collaborative activities funded reached 102 in 1997, up from 32 in 1993 (see Figure 3.9). The funds supporting these activities have fluctuated between \$6 million in 1997 and a low of \$1.9 million in 1993.

Of the various government agencies, NSF funds the largest number of projects with Canada. The average funding per project is \$61,000. The average duration of NSF-

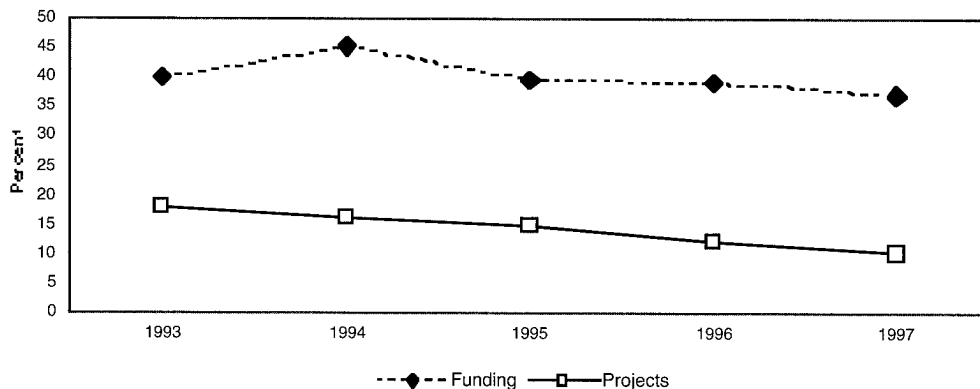


Figure 3.8—DHHS Funding and Number of Projects (% of total collaboration effort)

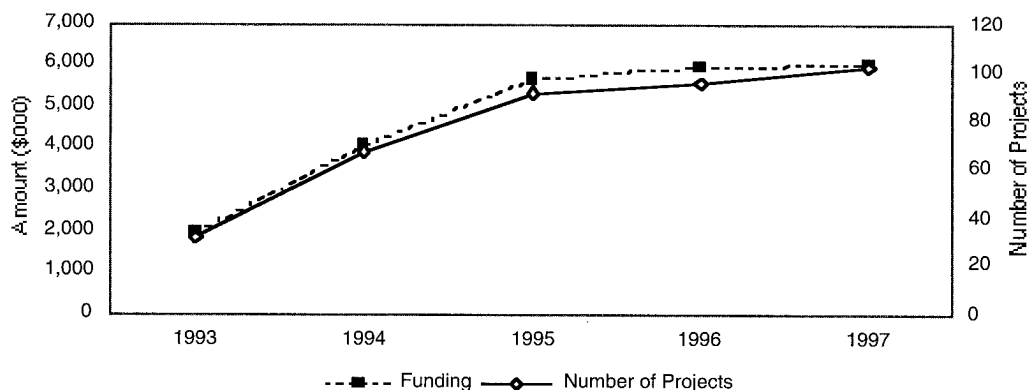


Figure 3.9—NSF Funding and Number of Projects

funded projects with Canada is two years. Nevertheless, long-term relationships are reported to have been established between scientists: These scientists often report continuing to work together on related projects for long periods, even after the NSF grant funds run out.

The NSF projects with Canada range across scientific fields. Biomedical research and earth sciences are the most frequently represented. The NSF directorates most often responsible for funding projects with Canada are Social, Behavioral, and Economic Sciences; Geosciences; and Biological Sciences. Examples of NSF projects include an investigation of neural-immune interactions in the beluga whale, a collaboration between the Canadian Department of Fisheries and Oceans, Native Canadian Hunters, and the U.S. Naval Command, Control, and Ocean Surveillance Center, and U.S. and Canadian scientists working together to collect and geochemically analyze samples of neoproterozoic rocks in northwestern Canada.

### Department of Veterans Affairs

The DVA accounts for the sixth largest amount spent with Canada, an average of \$1.3 million per year, and the second largest number of collaborative projects, 195 funded overall. In recent years, DVA has taken a leading role among agencies in the number of projects, funding up to 82 projects in 1997. Although both funding and number of projects increased during the period studied, average funding per project has decreased over time to just over \$25,000 in 1997, down from \$34,000 in 1993.

The majority of projects DVA has undertaken cooperatively with Canada are in biomedical sciences and include clinical trials to determine the worth of Tamoxifen for preventing breast cancer and a project to study host-bacterial interaction in the pathogenesis of severe group A streptococcal infections. Figure 3.10 outlines the extent of DVA's increase in collaborative research with Canada.

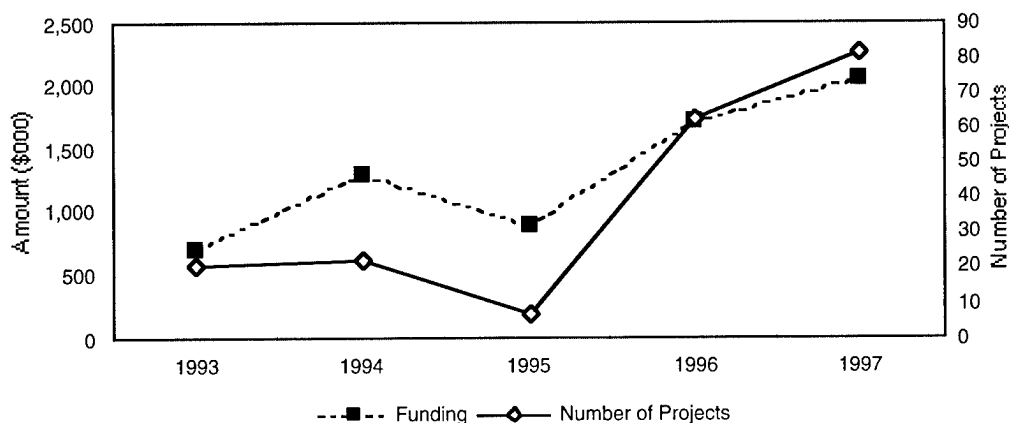


Figure 3.10—DVA Funding and Number of Projects

### Other Agencies

The DOE, EPA, USDA, DOD, NASA, and DOC also fund cooperation with Canada. USDA has only had a sporadic relationship with Canada, at least with respect to R&D funding. The DOE has funded an average of five collaborative projects per year, while the DOC has funded an average of two projects per year (Figures 3.11 and 3.12). Together, these two agencies account for about 3.5 percent of all collaborative R&D projects funded and 25 percent of all funding. Projects funded by these agencies include

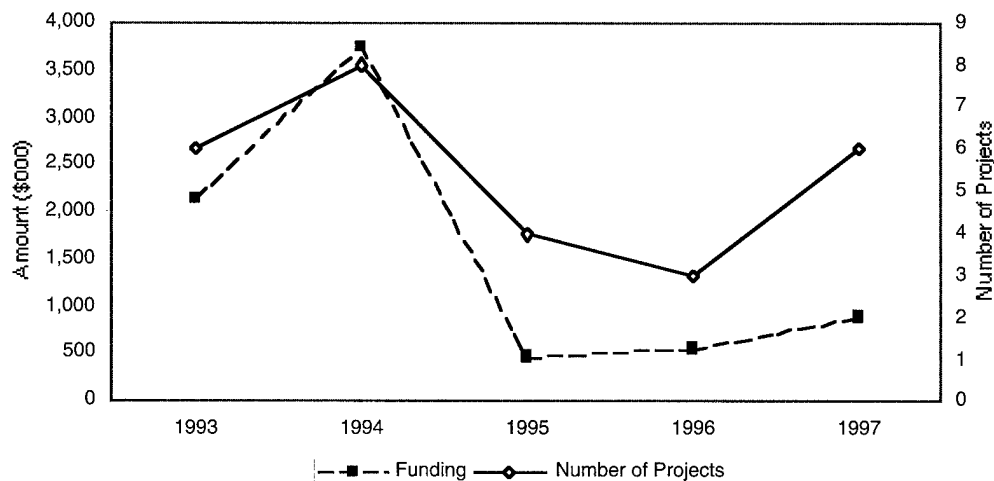


Figure 3.11—DOE Funding and Number of Projects

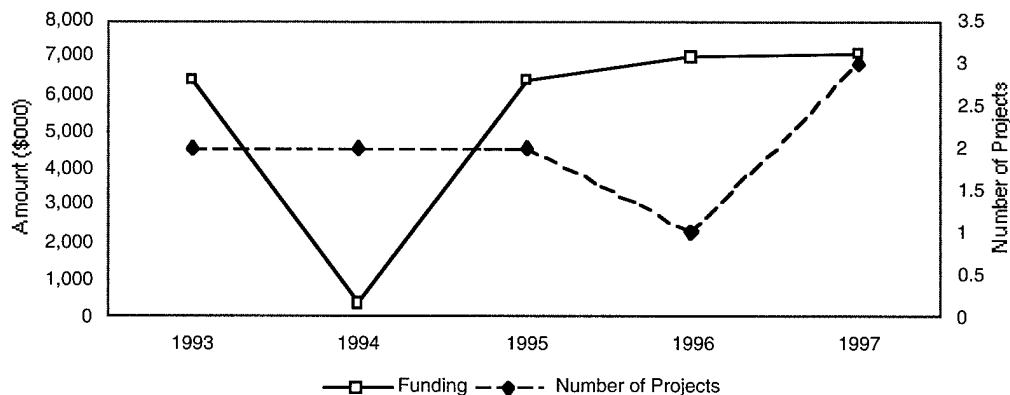


Figure 3.12—DOC Funding and Number of Projects

- atmospheric tracing to provide DOE with the capability to assess the validity of atmospheric models that predict the transport and dispersing of pollutants
- a project to support and integrate existing and future spent-fuel testing and model development activities.

EPA funds R&D in the Great Lakes region through its Great Lakes National Program Grants. This program includes such projects as

- a report on biodiversity investment
- toxaphene in the food chain of Lake Superior.

**DOD.** The DOD participates in a number of international arrangements in which a strong relationship with Canadian counterparts is evident. We interviewed a number of actors within DOD and the Canadian Department of National Defence in an effort to represent the nature of this relationship. Similar to interviewees in other departments, DOD and Department of National Defence officials stressed the close but sometimes informal relationship between the two countries in both the binational and the multinational arenas.

Three formal programs provide vehicles for U.S.-Canada cooperation in defense:

- The Research and Technology Organization, through the North Atlantic Treaty Organization, in which the United States, United Kingdom, and Canada enjoy a particularly strong relationship. Funds come in on an opportunity basis. Canada participates in all panels and in some of the working groups.
- The TTCP, which counts among its participants the United States, Canada, and Australia and in which the funds leveraged top \$100 million per year. According to Canadian officials, Canada participates in about 60 percent of these activities (approximately \$60 million). Projects are divided into tasks by country, with the final research results compiled and shared once these tasks are completed.
- Technical R&D Program (TRDP), a trilateral program involving the United States, Canada, and the United Kingdom. This program focuses on biochemical defense.

Although the cooperative relationship between the United States and Canada is extensive, there are concerns among Canadian officials about what is seen as bureaucratic mechanisms in the U.S. government that limit collaborative activities. Also, the large investment usually required for defense projects forces Canada to focus its cooperative research activities on areas in which it perceives it has strengths: biochemical detection and protection, submarine warfare, and electronic warfare.

**NASA.** NASA constitutes one of the principal U.S. government agencies collaborating with Canada. Since 1993, 22 projects, on average, have taken place each year in collaboration with Canadian counterparts. The majority of these projects are multinational. This is in keeping with NASA's focus on multinational cooperative activities.

Specific funding information for collaborative activities between NASA and Canadian counterparts has been difficult to decouple from funding for large-scale activities. With a few exceptions, funding attached to projects in this inventory represents an average figure or an estimate, as reported to us by NASA. On average, NASA spent about \$100,000 per project annually on those identified for this report. For 1993–1997, NASA's collaborative projects with Canada received as much as \$10.3 million in total funding. Much of this funding is matched at some level by Canadian government agencies.

Apart from the R&D projects identified for this study, Canada participates in such NASA programs as Mission to Planet Earth and the International Space Station, through the Canadian Space Agency. Canadian development funds allocated to the space station are on the order of \$1.2 billion over the length of the project.

### **Multinational R&D Activities**

Scientists and researchers from the United States and Canada collaborate on international cooperative activities involving several nations. Of the types of activities identified for this report, multinational R&D in which both Canada and the United States participate consistently leads in terms of funding and was third in terms of number of projects. Over the period studied, funding for multinational projects decreased overall, even while the number of multinational projects involving both countries increased.

In 1993, U.S. government funding for multinational projects involving the United States, Canada, and others was at least \$29 million and was probably more. By 1997, U.S. funding for multinational projects involving the United States and Canada had decreased slightly to \$22.9 million. Multinational activities are, for the most part, concentrated in the areas of atmospheric sciences, biomedical sciences, and physics. Some examples of multinational activities are

- DOC's climate and air quality control project and the International Satellite Cloud Climatology Project
- DHHS's international survey to investigate the ethical views of geneticists in 34 nations with the purpose of providing information on which to base discussions of law and government policy
- professional ethics within the various nations that may collaborate on the Human Genome Initiative between the United States and other countries.

In addition to these multinational projects, the United States, Canada, and Mexico maintain a growing trilateral relationship. In 1993, only three trilateral projects were funded, compared to 21 by 1996 and 20 in 1997. Likewise, funding for these types of activities grew from \$800,000 in 1993 to \$2.5 million in 1996 and \$2 million in 1997. Projects include the Center for North American Studies, which develops linkages with recognized agricultural programs in Mexico and Canada, and through the Department of Education, the financing of several student exchanges between the three countries.

## OTHER R&D ACTIVITIES

A number of R&D activities, such as conferences, database development, operational support, and standards development, are also part of the U.S. R&D relationship with Canada. Funding for these activities has consistently accounted for around 10 percent of total spending. NSF and DHHS financed most of the joint conferences, while NASA and DOE funded most database development projects in earth sciences and physics.

Infrastructure development activities include operational support, such as financing the use and operation of research facilities and the development of standards that scientists and researchers around the world use. DHHS finances most of these activities, which concentrate on the areas of lab maintenance (operational support) and the creation and dissemination of common standards for the use of scientists working on joint projects. Examples of these activities include

- a DHHS multiphase project, with an in-depth review of current practices, undertaken in six U.S. and six Canadian settings to develop, implement, and evaluate evidence-based practice guidelines to assist cancer risk information providers
- a DOE project to harmonize Canadian and U.S. window standards.

## CONCLUSION

The U.S. relationship with Canada in science and technology is thriving. Although funding levels have decreased modestly, the number of joint projects has jumped by more than 50 percent during the period studied. For example, U.S. and Canadian researchers are finding more ways and more areas of science in which to collaborate. The U.S.-Canadian relationship in science and technology appears to be one of the most important U.S. partnerships.

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**AN OVERVIEW OF FINDINGS: U.S.-MEXICO COOPERATION**

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**AN OVERVIEW OF FINDINGS**

In FY93 through FY97, the U.S. federal government spent, on average, \$26 million a year on all types of projects involving cooperation in R&D with Mexico. When counting just binational cooperation (excluding such multinational projects as space stations or global climate change research), money spent on activities with Mexico put that country among the top ten relationships the United States maintains in international cooperation in R&D. (Wagner, 1997, pp. 16–18.)

The binational activities with Mexico include scientist-to-scientist collaboration on a specific research question or project. Also included are technical support activities the United States funds to aid Mexico, such as agricultural or public-health support and pollution studies. Such activities as infrastructure support—database development or operational support for international laboratories—are also part of the funds going to cooperation between the United States and Mexico. U.S. cooperation with Mexico spans many areas of science and technology, but the largest number of projects and the greatest amount of money are spent in the life sciences.

**THE CHARACTER OF RESEARCH AND DEVELOPMENT WITH MEXICO**

The U.S.-Mexican relationship in R&D grew from 1993 to 1997. Figure 4.1 shows that the trend in binational cooperation is marked by an increasing emphasis on binational collaborative projects involving both U.S. and Mexican scientists. This trend is followed closely by an increase over a four-year period of U.S. scientists offering technical support to their Mexican counterparts (technical support dropped off in FY97 in favor of collaborative projects). In addition to binational research activities, U.S. and Mexican scientists cooperate as part of international projects, such as on health problems in Central and South America.

The cooperative R&D activities are marked by

1. the dominance of scientist-to-scientist collaboration, which accounts for 55 percent of funded activities during the period; these types of activities also increased at a greater rate—close to 25 percent over the five-year period—than other types of activities



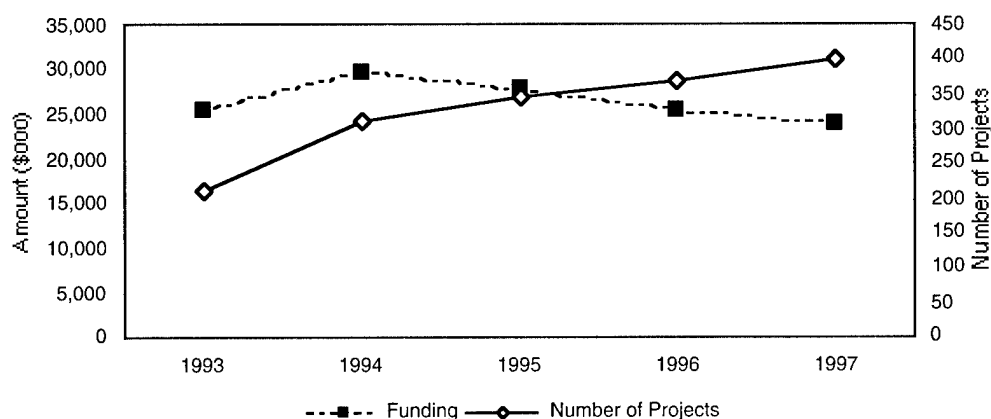


Figure 4.1—U.S.-Mexico Cooperative Research: Number of Projects and Spending

2. an emphasis on technical support—where a U.S. researcher provides information or assistance to a counterpart in Mexico, accounting for over 25 percent of the aggregated annual spending
3. other support activities, including database development, standards development, conferences, and operational support, accounting for approximately 5 percent of the U.S. contribution to the cooperative relationship
4. some participation by scientists from both nations in multinational cooperation—activities in which a number of countries, including the United States and Mexico, contribute to a common undertaking—accounting for approximately 14 percent per year of U.S. spending with Mexico over the 1993–1997 period.

By subject, environmental sciences, biomedical sciences, materials science, and engineering are the predominant areas of inquiry for cooperative activities. NSF, DHHS, and USDA together account for as much as 70 percent of funds contributed to this relationship.

### COLLABORATIVE RESEARCH WITH MEXICO, 1993–1997

Binational R&D activities involving researchers from Mexico and the United States account for about 86 percent of the R&D money the U.S. government spent on cooperation with Mexico. The remaining funds support multinational cooperative projects in which Mexico is involved as a partner. Among the binational cooperative activities are scientist-to-scientist collaboration, technical support, and other infrastructure support. Collaborative research between scientists from both nations and technical support—both activities in which researchers from both countries work closely together—account for an average of 80 percent per year of all 1993–1997 U.S.-Mexico R&D projects. U.S. government agencies funded the binational projects, in some cases with matching or augmented funds from the Mexican government. Funds are spent in either or both countries, but most of the spending likely occurs in the United States. The next subsection describes the nature of the projects involving scientist-to-scientist collaboration.

During 1997, U.S. government funding for collaborative projects with Mexico climbed to its highest amount in five years, with collaborative R&D claiming over 67 percent of total cooperative spending.<sup>1</sup> With the exception of 1995, when an anomalous decline occurred, there was a small increase in the proportion of total spending dedicated to collaborative R&D in the U.S. relationship with Mexico (Figure 4.2). A growing trend is evident in the *number* of binational projects funded, which climbed to a total of 297 collaborative projects in 1997 from 143 in 1993. This climb represents an increase of more than 107 percent, with the greatest gains occurring from 1993 to 1994 and from 1996 to 1997.

Technical support activities—in which a U.S.-funded researcher aids Mexican counterparts in some aspect of science or technology—increased significantly between 1993 and 1996. At its peak in 1996, funding for U.S. technical support to Mexico this type of activity represented close to 35 percent of total binational spending. This trend turned downward in 1997, when spending for technical support decreased to just over 15 percent of the total in favor of spending on collaborative research projects, as illustrated in Figure 4.3

### Fields of Science Represented in Binational Collaboration

In an effort to understand the type of government-funded scientific activity taking place between the United States and Mexico, projects were categorized by areas of science. This is an imperfect, largely subjective activity, but the results give gross indicators about the type of science taking place over time. The list of areas of science used for this effort was derived from a list developed by the National Science Board (NSB). Using the NSB list as a guide, 16 areas of science were identified as the

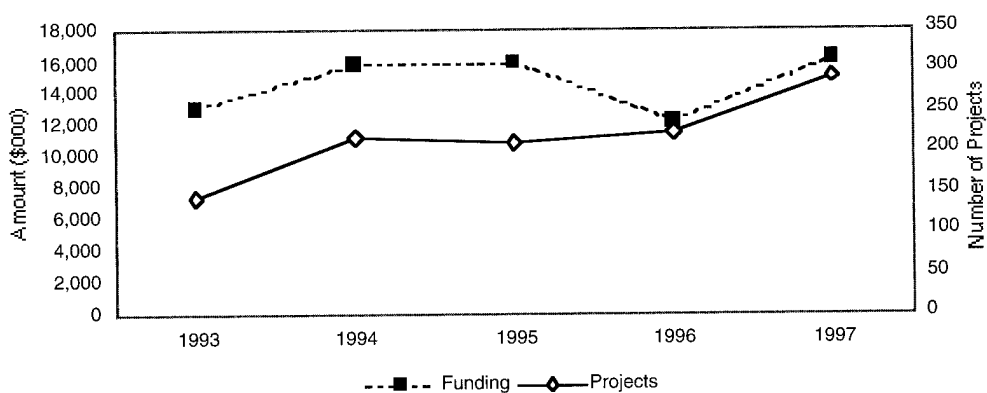
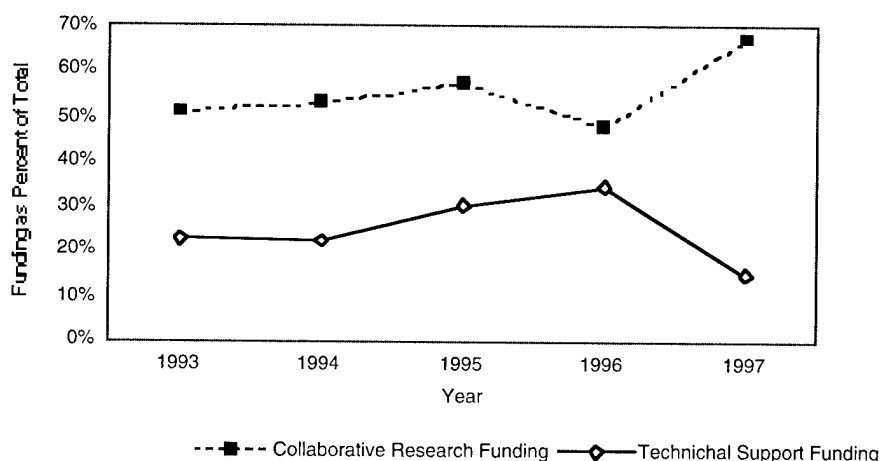


Figure 4.2—Number of Projects and Spending on Collaborative Research

<sup>1</sup>This amount also includes activities in which a U.S.-funded researcher is conducting research about Mexico and in which the researcher plans to visit Mexico and, as is generally the case, provide information to Mexican counterparts.



**Figure 4.3—Funding for Binational U.S.-Mexico Collaboration and Technical Support as a Percentage of Total Spending**

most common subjects of collaborative and technical support projects between the United States and Mexico. The area of science most frequently represented in binational projects during the 1993–1997 period is environmental sciences, which account for as much as 31 percent of the total number of projects. Materials sciences and engineering, which represented anywhere from 7 to 17 percent, and biomedical sciences, which account for 9 to 23 percent of the total, are also significant parts of the binational relationship. Table 4.1 outlines the percentage share of the number of projects for each area of science.

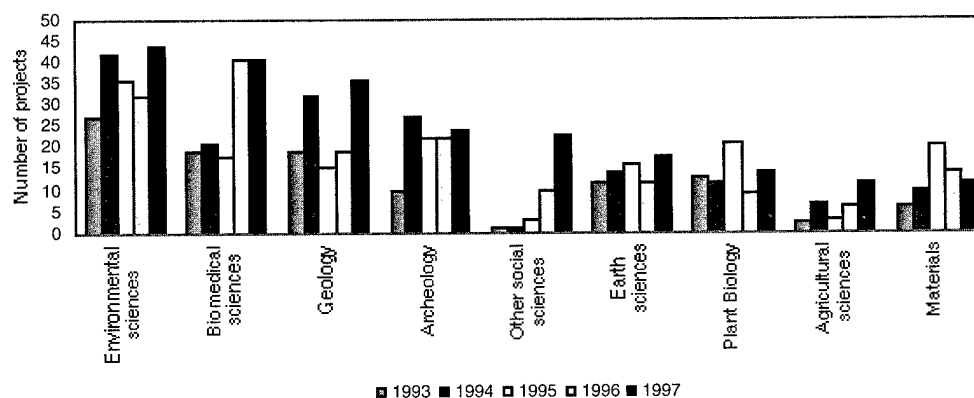
The areas of science represented in the binational relationship are highly variable over time and as part of the total. The most notable change is probably in the area of computer science and engineering, which increased from next to nothing in the 1993–1995 period, to nearly 5 percent of the total in 1997. In the aggregate, environmental, earth, biomedical, and agricultural sciences together accounted for an average of 70 percent of total funding over the five-year period. Projects within the life sciences account for a considerable share—as much as 50 percent of total activities from 1993 to 1997—while the social sciences account for only 8 percent.<sup>2</sup> Figures 4.4 and 4.5 outline the number of collaborative projects undertaken as well as the funding for these activities.

<sup>2</sup>A considerable amount of social-science activities, such as education and training, may go on with Mexico, but these would not be captured by an inventory of R&D spending. In general, education and training funds are not counted as R&D.

**Table 4.1**  
**Percentage Share of Funding of U.S.-Mexican Projects for**  
**Different Areas of Science, 1993–1997**

		1993	1994	1995	1996	1997
Biomedical	↑	13.8	13.3	13.7	19.7	28.0
Environmental science	↑	3.0	13.5	42.3	11.6	20.3
Geology	—	9.6	8.1	3.8	7.4	10.7
Other life science	↑	3.3	2.7	2.3	9.5	8.5
Other social sciences	↑	0.5	0.0	0.1	1.2	6.2
Earth sciences	↓	54.1	37.8	4.0	4.9	5.1
Chemistry	↑	0.6	0.0	0.0	5.5	4.1
Archaeology	↑	1.6	4.7	3.5	4.5	3.6
Anthropology	↑	1.0	0.0	2.5	3.3	2.7
Agricultural science	↑	1.0	6.1	17.4	23.6	2.5
Plant biology	↓	6.6	3.7	4.5	3.2	2.2
Economics	↑	0.8	0.4	0.1	0.2	2.1
Computer engineering	↑	0.0	0.0	0.0	1.3	0.9
Materials	↑	0.2	0.2	1.1	0.5	0.8
Demographics	—	0.0	3.4	1.4	0.9	0.6
Other physical science	↑	0.0	0.0	0.0	0.0	0.5
Mathematics	—	0.3	0.1	0.1	0.5	0.4
Physics	—	0.1	0.3	0.3	0.5	0.4
Biotechnology	↓	1.3	1.1	0.4	1.6	0.2
Other engineering	↓	2.2	4.5	2.4	0.1	0.1

NOTE: arrows indicate funding movement between 1993 and 1997.



**Figure 4.4—Number of Collaborative Projects by Area of Science**

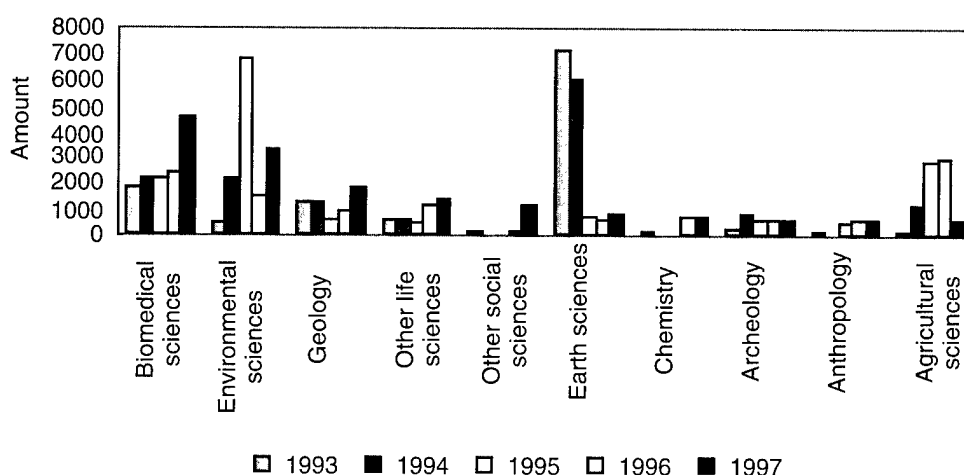


Figure 4.5—Funding for Collaborative Projects by Area of Science

### Government Agencies Supporting Binational Collaboration

A total of 12 government agencies support binational collaboration with Mexico, with eight of them consistently funding projects over the period studied. The National Science Foundation leads in both number of projects and total funding allocated to binational collaboration with Mexico. Other agencies providing funding include DHHS, EPA, DOE, NASA, USDA, USAID, and DOC. Figures 4.6. and 4.7 show the share of projects and funding among the agencies.

**National Science Foundation.** The NSF has consistently funded binational collaborative scientific activities with Mexico. Based on the excellence of the proposals offered for cooperative scientific projects with Mexican counterparts, NSF has awarded grants for proposals for collaborative research at an average of nearly \$3.5 million per year. In addition, NSF has established a comprehensive agreement with the Mexican government's CONACYT to ensure smooth and ongoing relationships between the two agencies.

The number of NSF binational activities funded each year has increased to 141 in 1997 from 70 in 1993. The funds supporting these activities have also grown to over \$4.5 million in 1997 from just over \$2 million in 1993. Although the average duration of NSF-funded projects is two years, these scientists often report continuing to work together on related projects for long periods.

The NSF projects fund cooperation with Mexico across a range of scientific fields. Biomedical research and environmental sciences are the most frequently represented. The NSF directorates most often responsible for funding projects with Mexico are Social, Behavioral and Economic Sciences, which includes the office of International Cooperative Scientific Activities; Geosciences; Biological Sciences; Engineering; and, increasingly, Computer and Information Science and Engineering. In keeping with the nature of its funding, the projects NSF funds tend to be smaller than those of other agencies, with an average annual funding of \$32,000 per project. Examples of projects include

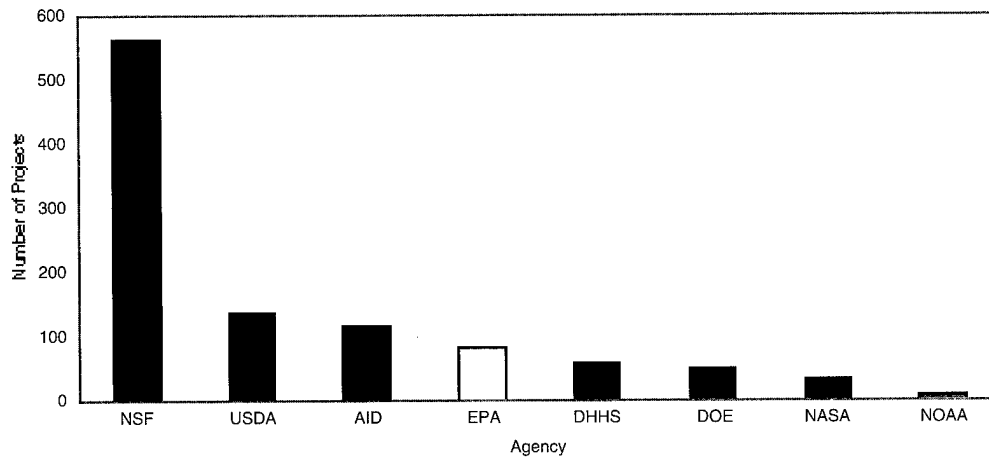


Figure 4.6—Aggregate Number of Collaborative U.S.-Mexico Binational Projects by Agency, 1993–1997

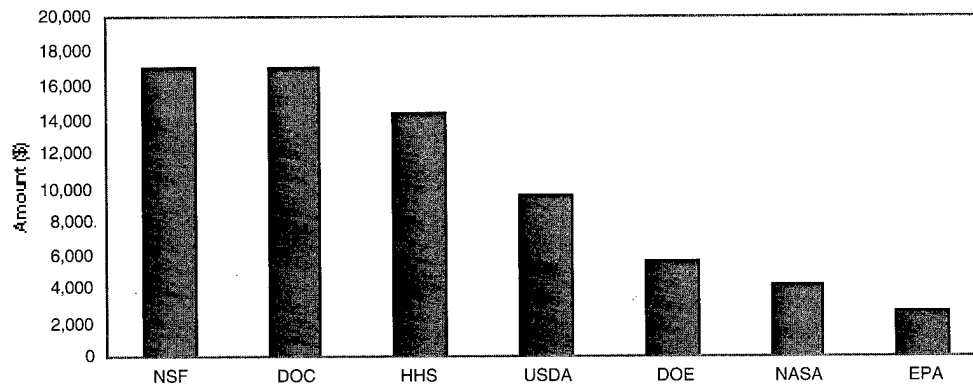


Figure 4.7—Aggregate Funding of Collaborative U.S.-Mexico Binational Projects By Agency, 1993–1997

- experimental research among geographically dispersed groups in artificial intelligence—a collaborative undertaking between the Department of Computer Science at Stanford University and the Center for Artificial Intelligence at Instituto Tecnológico y de Estudios Superiores de Monterrey, in Monterrey, Mexico
- a project involving the synthesis and characterization of solid “superacids,” undertaken by the University of California at Berkeley, the Exxon Corporation, and the Metropolitan Autonomous University at Iztapalapa in Mexico.

**Department of Health and Human Services.** From 1993 to 1997, DHHS funding of joint projects with Mexico has fluctuated, as have the number of projects being undertaken in any given year (Figure 4.8). In 1993, DHHS funded 17 projects involv-

ing U.S.-Mexico cooperation, for a total of \$1.9 million. In 1994, 21 such projects were funded, for a total of \$3.3 million, with a similar pattern in 1995. A slight reversal took place in 1996, when 45 projects were funded for a total of \$2.4 million. In 1997, spending increased dramatically to \$4.4 million, for a total of 31 binational projects.

Figure 4.8 illustrates the highly variable nature of DHHS funding for U.S.-Mexican binational collaborative activities. These activities are concentrated in the areas of biomedical sciences and environmental sciences. Unlike NSF, which funds researcher-to-researcher collaborations, the projects DHHS funds are often collaborations between institutions—such as the CDC or NIH and their Mexican counterparts. The largest amount of funds spent on DHHS collaborative activities with Mexico came through the NIH.

Part of the funding surge in 1994 included a four-year, \$806 million-per-year environmental health-sciences project; a cancer control project with \$472 million in annual funding; and a project on community-based human immunodeficiency virus (HIV) risk reduction with \$268 million in annual funding from 1993 to 1996. In 1997, a project was initiated to measure visual impairment of Mexicans residing in Sonora State. This project alone accounted for close to \$1.2 million in annual funding through 1998, causing most of the funding increase observed between 1996 and 1997.

**Environmental Protection Agency.** Most collaborative activities undertaken by the EPA with Mexican counterparts are implemented through the Southwest Center for

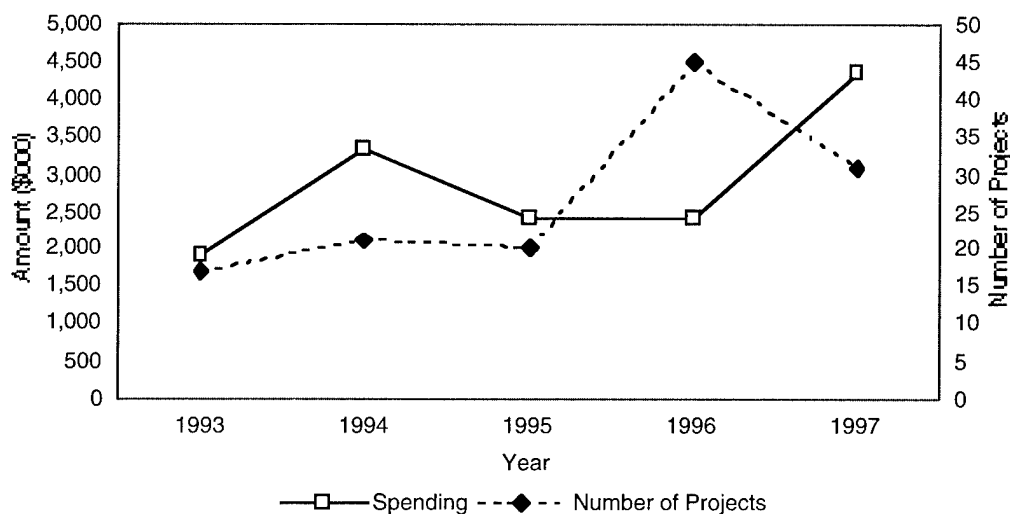


Figure 4.8—DHHS Funding for Collaboration with Mexico and Number of Binational Projects, 1993–1997

Environmental Research and Policy (SCERP).<sup>3</sup> SCERP is a consortium of U.S. and Mexican universities working together on environmental issues on the border. Participating universities include Arizona State University, New Mexico State University, San Diego State University, the University of Texas, and the University of Utah. On the Mexican side, the participants are Instituto Tecnológico de Ciudad Juárez, Instituto Tecnológico y de Estudios Superiores de Monterrey, Universidad Autónoma de Baja California, and Universidad Autónoma de Ciudad Juárez. Most projects undertaken are in air quality, water quality, and control of toxic materials. In addition to these projects, SCERP conducts outreach efforts, such as community forums and environmental training. According to SCERP officials, total funding for that agency's activities for 1993, 1994, and 1995 amounted to approximately \$2 million per year. During 1996 and 1997, approximately \$2.5 million per year was allocated. Each year of operation, between 20 and 30 joint projects were funded through SCERP.

The EPA also participates in activities under the Border XXI program—a binational effort that facilitates cooperation between Mexico and the United States in the areas of sustainable development in the border region. Even though substantial funding has been allocated to this program, as much as \$100 million over three years, it is not represented here because spending is budgeted as capital expenditures rather than as R&D.

In addition to these activities, the EPA funds projects in nonborder regions. Spending on these projects amounted to approximately \$0.5 million per year from 1993 through 1997.

**U.S. Agency for International Development.** USAID budgets R&D funds to support cooperation with and infrastructure and technical support to Latin American countries. USAID has a comparatively small R&D budget (most of its funds are budgeted in a capital and investment account), and it is difficult to ascertain the amount of funding devoted to specific cooperative projects with Mexico. With the help of USAID officials, this inventory counts an annual figure of \$3 million dedicated to some form of USAID R&D cooperation with Mexico (Figure 4.9).<sup>4</sup>

In addition to its activities with other U.S. government agencies, USAID also sponsors a program titled "Environmental and Natural Resource Management in Mexico." This program, combining both R&D and programmatic funds from the U.S. and Mexican governments, as well as international (e.g., the World Bank, the Inter-American Development Bank), private (e.g., Bechtel), and philanthropic actors (e.g., MacArthur Foundation), focuses on five issues:

- terrestrial biodiversity conservation

<sup>3</sup>Funding for this center is appropriated by Congress under the Clean Air Act.

<sup>4</sup>This number was arrived at by taking the R&D amount dedicated by USAID to Latin America, then dividing that amount according to each country's population relative to other Latin American countries. Mexican funding corresponds to 20 percent of the total USAID funds devoted to this type of activity throughout Latin America, an estimate that matches the funds known to have been received in Mexico and that USAID officials indicate is the approximate figure for funds allocated to Mexico.



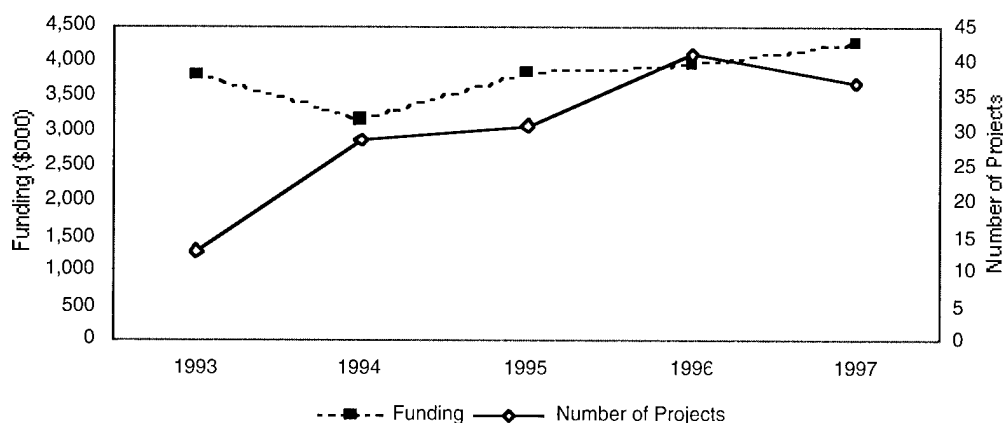


Figure 4.9—USAID Funding and Number of Projects

- forest conservation and monitoring
- energy and climate change
- urban environment, including water supply and sanitation activities
- coastal and marine resources management and biodiversity conservation.

Between 1993 and 1996, this program leveraged funds and coordinated activities on over 100 projects in these different focus areas.

Other activities that USAID funds are technical support and are undertaken by the Bureau for Global Programs, Field Support, and Research. This bureau funds projects—strictly with programmatic, not R&D funds—that serve to provide health services and some studies of health problems in Mexico. Most of the 14 programs identified for this study focus on family and reproductive health. Overall, the areas most commonly represented in the bureau's portfolio are environmental sciences, demography, and biomedical sciences.

The U.S.-Mexico Science and Technology Foundation, established in 1992 in Mexico City, is one place where USAID actively funds scientific and technical projects in Mexico. Through grants from the U.S. and Mexican governments, the foundation finances binational research in environment, public health, and socioeconomic issues that have occurred as a result of increased U.S.-Mexico connections. According to foundation officials, out of 600 proposals received by the foundation in 1993 and 1994, 24 were funded. Foundation projects include research projects, fellowships, visiting scientists, and university exchanges.

In addition to academic and scientist exchange programs, the foundation funds R&D in the border regions, such as the Materials Corridor Partnership Initiative, designed to establish public-private partnership in the development of environmentally friendly materials technologies and industries along the border. The foundation has also supported water-related projects in the border region. The umbrella agreement under which these water-related projects take place has allowed the foundation to

finance studies and capacity-building for cooperation with the Border Environment Cooperation Commission, the North American Development Bank, the Comisión Nacional de Agua, and the International Boundary and Water Commission.

USAID and other U.S. government-agency funds are provided to R&D projects through Mexico's science agency, CONACYT, which matches the U.S. government funds. Prior to FY98, the U.S.-Mexico Foundation for Science was funded by the U.S. and Mexican governments with a total of approximately \$3 million a year, according to National Academy of Sciences officials. U.S. funds originally were provided to the foundation through the U.S. National Academy of Sciences and USAID.

In FY99, President Bill Clinton requested another \$5 million per year between 1998 and 2003 for the foundation. The Mexican government, though CONACYT, has committed to match these funds.

According to foundation staff, it has been successful in other quests for funding:

- The Hewlett Foundation awarded the U.S.-Mexico Science and Technology Foundation \$100,000 per year over the subsequent three years for setting up workshops in advanced research techniques.
- The EPA Border XXI project has provided approximately \$1.5 million to undertake water-related projects in the border region.

**U.S. Department of Agriculture.** Throughout the period studied, USDA has had an ongoing relationship with Mexico, although funding has fluctuated significantly. In 1993, just over \$540,000 was spent on collaborative and technical support projects with Mexico. This amount increased to just over \$1.3 million in 1994, then to around \$3.3 million in 1995 and 1996. Funding then dropped in 1997 to just over \$630,000. The increase during 1995 and 1996 was due primarily to spending on a two-year U.S.-Mexico agroforestry development project operated through the U.S. Forest Service, with annual U.S. government funding of approximately \$2.7 million. The increase observed in 1994 corresponded with an increase in the number of projects funded, which went from 11 in 1993 to 24 in 1994. The number of projects decreased in 1995 to a level comparable to that of 1993 (Figure 4.10).

Many of USDA's collaborative projects with Mexico are undertaken by the Cooperative State Research, Education, and Extension Service. All projects funded through this bureau are appropriated through the Hatch Act. Money is transferred to the Cooperative Extension Services at the state level to be allocated to cooperative projects. This transfer of funds makes tracking difficult because the states are not required to report how they allocate funds. Each state is charged with recordkeeping; when contacted by RAND, the state offices provided accurate information. Because of the funds-transfer mechanism, it is possible that USDA's cooperative activities with Mexico have been underreported, and states may have engaged in activities not captured in our data-collection effort. We did inquire generally about such activities, and Texas reported the only additional project.

**National Aeronautics and Space Administration.** Since 1993, NASA has undertaken an average of 12 projects each year in collaboration with Mexican counterparts. The

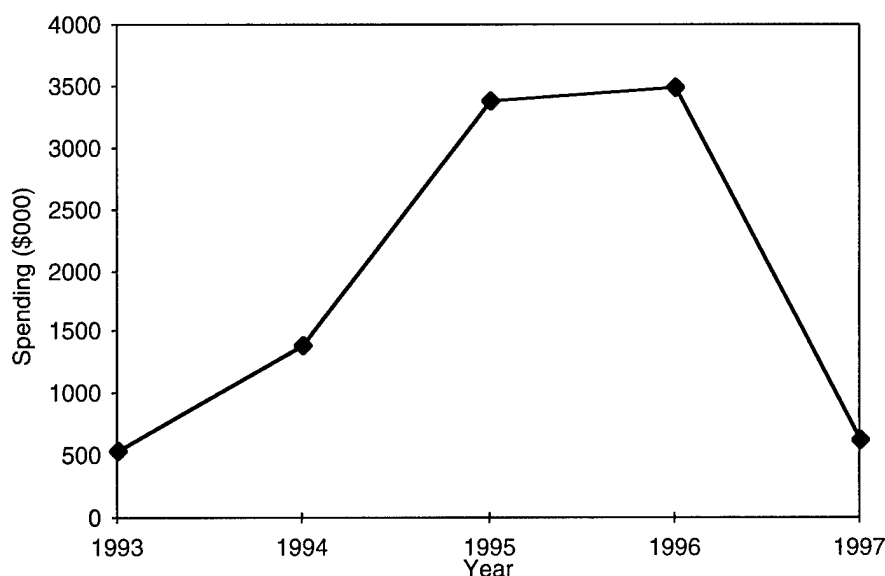


Figure 4.10—USDA Spending on Collaborative Projects with Mexico, 1993–1997

majority of projects involving both NASA and Mexican counterparts, however, were multinational. This is in keeping with NASA's focus on multinational cooperative activities.

Specific funding information for collaborative activities between NASA and Mexican counterparts is difficult to obtain from NASA. With a few exceptions, funding attached to projects in this inventory represents an average funding figure reported by NASA. On average, for projects identified in this inventory, NASA spent \$100,000 per project per year. For 1993 through 1997, NASA's collaborative projects with Mexico were funded at approximately \$4.2 million (see Figure 4.11).

**Department of Energy.** The DOE funds a small number of large projects with Mexico. In 1993, four earth sciences projects were funded at just below a total of \$1.5 million. By 1997, roughly \$1.8 million was being spent on 14 projects. These projects were funded out of DOE bureaus: Energy Supply, Fossil Energy, and Renewable Energy Education. About 70 percent of the projects were collaborations with Mexican counterparts, with the remaining being technical assistance.

In addition to activities funded with money from DOE headquarters, several of the DOE laboratories provide funds for cooperative activities with Mexico. Most active in this regard is Sandia National Laboratories in Albuquerque, New Mexico, through its Sandia-Mexico Program. Program funds total about \$5 million. The focus of this program is on off-grid rural energy applications of technology. Projects must have economic or social benefits, have built-in payback mechanisms, or be able to compete with other subsidized programs. Examples of activities include water-pumping stations for livestock and irrigation, communication infrastructure installation,

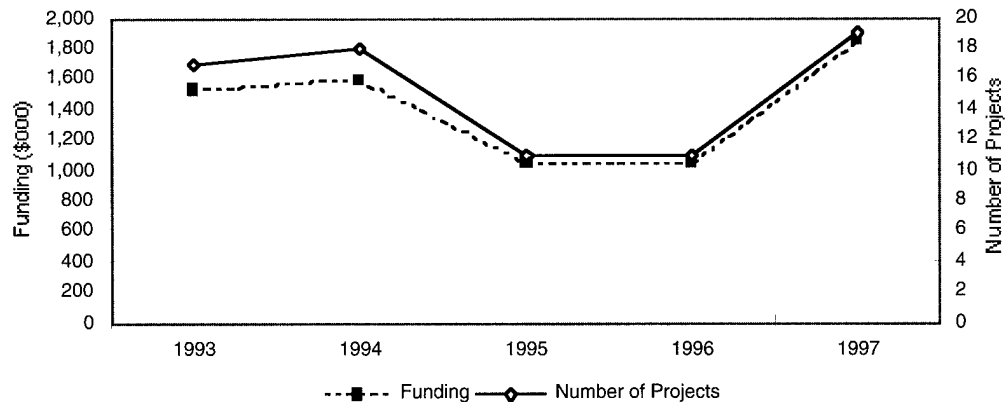


Figure 4.11—NASA Funding and Number of Projects

commercial lighting installation, and power provided to villages. In 1997, 30 projects were sponsored. Several organizations cooperate with the Sandia-Mexico Program, including the Southwest Technology Development Institute; Winrock International; Enersol Associates; the Mexican Ecoturismo y Nuevas Tecnologías, A.C.; and several U.S. industry organizations. Other labs funding small projects with Mexico include Los Alamos National Laboratory and Pacific Northwest National Laboratory.

**Department of Commerce.** DOC's participation in collaborative activities with Mexico is highly variable. Funding for such activities has dropped to about \$80,000 in 1997 from over \$5.5 million in 1993, with significant fluctuations in between. The fluctuation and drop are due to the funding and then completion of a single large project during the 1993–1995 period: The atmospheric measurement research project, a NOAA effort, had total annual funding of over \$5.5 million.

**Other Agencies.** Other agencies that participate in collaborative activities with Mexico are the DVA, with such projects as schizophrenia research through its Medical and Prosthetic Research Division; the DOD, through the Department of the Army; and the Department of Interior, through the USGS, which has a few small R&D projects with Mexico. Although USGS has a very small R&D budget, it is participating with Mexico in two large projects, not funded as R&D, that have a scientific component. According to USGS officials, these are a large border-water project and a border-mapping project. In the latter, USGS surveys the border on the U.S. side and shares this data with counterparts in Mexico to enable accurate mapping of the border region. A similar sharing of resources is taking place in the water project. These agencies and other scientific activities have provided an estimated \$400,000 for collaboration and technical support from 1993 through 1997.

#### Multinational Research Activities with Mexico, 1993–1997

Scientists and researchers from the United States and Mexico also collaborate in international cooperative activities involving other nations. Over the period studied,

funding for these projects decreased overall, while the number of multinational projects involving both countries increased (Figure 4.12).

In 1993, U.S. government funding for multinational projects involving the United States and Mexico amounted to \$6.3 million. By 1995, this amount had decreased to \$1.9 million and has remained steady at about that level. In proportion to total spending on cooperative activities with Mexico, multinational projects accounted for shares as follows: 1993, 25 percent; 1994, 21 percent; 1995, 6 percent; 1996, 6 percent; and 1997, 9 percent. At the same that time spending for these projects decreased, the number of projects increased, to a high of 45 in 1996 from 17 in 1993, the year the least amount of money was spent. In 1997, 23 multinational projects were funded.

Multinational activities are, for the most part, concentrated in research on physics, earth sciences, and plant biology. Agencies involved in these activities are most likely to be NASA, DHHS, and DOE.

Some examples of multinational activity include a single five-year project on plant biology with \$412,000 in annual DHHS funding. The objective of this project is to sustain economic growth and conserve resources through the development of pharmaceuticals and crop-protection agents from plants found in Latin American ecosystems. The DOE is funding a large multinational project for R&D activities associated with Fermilab's colliding beams experimental programs. U.S. government funding for this two-year project is over \$4.5 million per year.

## OTHER COOPERATIVE R&D ACTIVITIES WITH MEXICO

A number of R&D activities, such as database development, infrastructure development, and conferences, are also part of the U.S. R&D relationship with Mexico. Funding for these activities has consistently accounted for around 5 percent of total spending. Most of the joint conferences are financed by NSF through CONACYT (these activities are not included in the description of collaborative research described above), while most database development projects are funded through SCERP and are in the areas of environmental sciences and geology.

Infrastructure development activities include operational support, such as financing the use and operation of research facilities and the development of standards that are used by scientists and researchers around the world. Most of these activities are financed by DHHS and concentrate in the areas of lab maintenance (operational support) and the creation and dissemination of common standards for use by scientists working on joint projects. Examples include

- an electrification project in Chiapas and Quintana Roo being conducted jointly between Mexican government and Sandia counterparts and being cost-shared with Mexican end-users
- an DHHS project concentrating on helping central-level staff build the ability of state and jurisdictional decisionmakers to use data for planning, implementing, and evaluating public health programs.

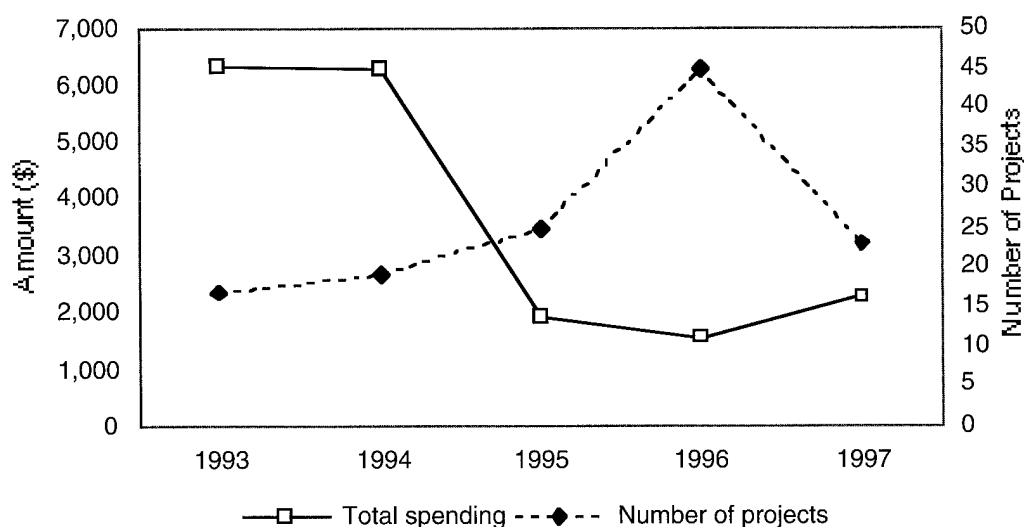


Figure 4.12—Spending on Multinational Activities and Number of Projects, 1993–1997

## CONCLUSION

The U.S. relationship with Mexico in science and technology is thriving. Notably, U.S. and Mexican researchers are finding more ways and more areas of science in which to collaborate. Research that is strictly *about* Mexico, but that has no Mexican counterpart, is decreasing in favor of true collaboration. This would appear to indicate an increasing confidence among U.S. researchers in their Mexican counterparts and vice versa.

Despite an increasingly healthy relationship, it would appear that there are places in which the interchange could be strengthened. The two countries tend to collaborate in the areas of environment and earth sciences, for example. Clearly, given our shared border, this is a logical area for collaboration. Even so, there is little in the way of collaboration in the higher technology areas, such as electronics and communications, in which both countries also have shared interests. Moreover, the bulk of the projects being conducted focus on applied R&D, with little being done in basic sciences, such as chemistry, physics, and space science. Given that Mexican scientists have shown international strength in these areas of science (Russell, 1998, pp. 113–124),<sup>5</sup> increased cooperation may be in order.

<sup>5</sup>On p. 115, Russell reports that Mexican scientists have made important contributions to international science in biomedicine, chemistry, physics, astronomy and astrophysics, and geosciences.

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## REFERENCES

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- Department of Foreign Affairs and International Trade, Science and Technology Division, *An Inventory of Federal and Provincial Science and Technology Arrangements*, Ottawa, Canada, July 1997.
- National Science Board, *Science and Engineering Indicators—1998*, Arlington, Va.: National Science Foundation, NSB98-1, 1998.
- Okubo, Y., et al., "Structure of International Collaboration in Science: Typology of Countries Through Multivariate Techniques Using a Link Indicator," *Scientometrics*, Vol. 25, No. 2, 1992.
- Organisation for Economic Cooperation and Development, *Internationalization of Industrial R&D: Patterns and Trends*, Paris, France, 1998.
- Organisation for Economic Cooperation and Development, *Main Science and Technology Indicators*, 1997.
- Russell, Jane M., "Publishing Patterns of Mexican Scientists: Differences Between National and International Papers," *Scientometrics*, Vol. 41, Nos. 1-2, 1998, pp. 113-124.
- UNESCO World Science Report, 1996.
- U.S. Department of State, Bureau of Oceans and International Environmental and Scientific Affairs, *Bilateral Science and Technology Framework Agreements*, Fact Sheet, April 21, 1999. Available at [http://www.state.gov/www/global/oes/science/fs-s&t\\_umbr\\_agrmts\\_990421.html](http://www.state.gov/www/global/oes/science/fs-s&t_umbr_agrmts_990421.html).
- Wagner, Caroline, *International Cooperation in Research and Development*, Santa Monica, Calif.: RAND, MR-900-OSTP, 1997.